Groundwater Five-Year Review

Executive Summary

Travis Air Force Base (Travis AFB or Base), with public and regulatory acceptance, is implementing interim groundwater remedies at multiple contaminated sites. This *Groundwater Five-Year Review Report* evaluates whether the interim remedies are protective of human health and the environment and are functioning as designed. Specifically, the five-year review provides the following information:

- States whether the interim remedy is, or is expected to be, protective
- Lists deficiencies identified during the review
- Recommends specific actions to ensure that a remedy will be, or will continue to be, effective

This first *Groundwater Five-Year Review Report* is required by statute and is prepared in accordance with the U.S. Environmental Protection Agency (EPA) *Comprehensive Five-Year Review Guidance* (EPA, 2001).

The interim groundwater remedies are being implemented in accordance with the *Groundwater Interim Record of Decision (IROD) for the North/East/West Industrial Operable Unit (NEWIOU)* (Travis AFB, 1997) and the *Groundwater IROD for the West/Annexes/Basewide Operable Unit (WABOU)* (Travis AFB, 1999).

The interim remedies were designed and constructed to quickly begin remediation of groundwater contamination, reduce the levels of contamination and potential risk, and collect some of the data necessary for the selection of final cleanup levels and technically and economically feasible long-term actions. The use of IRODs allowed actions to proceed without having final designated cleanup levels, as will be required for the Final Basewide Groundwater Record of Decision (ROD). The interim actions taken under the IRODs use interim remediation goals as performance objectives. These are not legally enforceable standards, but are simply goals during the period of interim long-term operation (LTO).

Travis AFB is the lead agency and responsible party for the groundwater remediation actions being evaluated in this first five-year review. The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), EPA, and Department of Toxic Substances Control (DTSC) provide regulatory agency oversight.

Funding of groundwater remediation efforts is provided by the Department of Defense to the Air Mobility Command. The Air Mobility Command then allocates these funds to Travis AFB according to priorities determined by the Air Force. Subsequently, the Air Force Center for Environmental Excellence (AFCEE) provides administration of these funds. The allocation of available funds is continually under review by the Air Force and is subject to alteration. Such funding changes are typically outside the control of Travis AFB. Accordingly, the precise schedule of groundwater remediation efforts is uncertain. Table ES-1 shows that optimization opportunities/further actions are identified for some sites (located at the end of this executive summary). A detailed schedule cannot be developed at this time, but Travis AFB will consult with the SFBRWQCB, EPA, and DTSC to develop a schedule that is acceptable to all parties.

Background

Physical Setting

Travis AFB occupies approximately 6,000 acres and is located midway between San Francisco and Sacramento, California. Facilities include two major runways, associated taxiways and aircraft parking aprons, numerous hangars, buildings, shops, offices, freight handling and storage areas, and maintenance facilities. Approximately 17,000 military and civilian personnel are present daily on the Base.

Travis AFB is part of Air Mobility Command and is host to the 60th Air Mobility Wing and other units. The Air Mobility Wing operates C-5 Galaxy cargo aircraft and KC-10 Extender refueling aircraft. The primary missions of Travis AFB, since its establishment in 1943, have been strategic reconnaissance and airlift of freight and troops.

Groundwater Contamination

As a result of past waste management and disposal practices, groundwater at Travis AFB is contaminated at multiple locations.

The locations of groundwater contamination and Installation Restoration Program (IRP) sites are shown on Figure ES-1 and Plate 1.

The primary groundwater contaminants exceeding the interim remediation goals established by the NEWIOU and WABOU IRODs include chlorinated volatile organic compounds, primarily trichloroethylene and related compounds. Petroleum-fuel constituents, organochlorine pesticides, and other contaminants are also present in some places.

Interim Remedial Action Objectives

Groundwater interim remedial actions (IRA) have, as specified in the two IRODs, been designed and constructed to achieve the following basic interim remedial objectives:

- **Source Control** – hydraulically contain and remove contaminant mass from the groundwater and vadose zone using groundwater extraction and treatment (GET) and vapor extraction and treatment
- **Migration Control** – hydraulically contain contamination using a GET system and/or program of monitored natural attenuation (MNA)
- **Offbase Remediation** – hydraulically contain and remediate plumes down to the contaminant-specific interim remediation goal using a GET system

A summary of the IRA objectives for each IRP site is provided in Table ES-1.

Monitored Natural Attenuation

The Natural Attenuation Assessment Plan (NAAP) is the governing document for sites, or portions or sites, undergoing assessments of MNA (CH2M HILL, 1998). The protocols provided in the NAAP are the basis for determining if the Migration Control objective has been achieved and the contaminant plume has been stabilized through natural physical, chemical, and biological processes.

In accordance with the IRODs and NAAP, multiple sites at Travis AFB are undergoing MNA assessment during the period of interim remedial action. These sites include:

- LF006 – formally selected for MNA in the NEWIOU Groundwater IROD
- FT004 – MNA assessment combined with GET
- SD031 – MNA assessment combined with GET

Figure
ES-1 Consolidated Groundwater Interim Remedial Actions
11 x 17 color

Figure ES-1 continued

- LF007B – MNA assessment
- LF007C – MNA assessment combined with GET
- LF007D – MNA assessment
- SS014 – petroleum fuels commingled with chlorinated hydrocarbons
- SD033 – MNA assessment combined with GET
- SD037 – MNA assessment combined with GET
- SS015 – MNA assessment deferred pending enhanced biodegradation treatability study
- DP039 – combined with GET, reactive wall treatability study, and phytoremediation treatability study

The listed sites initially underwent preliminary assessment of biodegradation factors as part of the preparation of Natural Attenuation Assessment Work Plans. The plans established that, on an ongoing basis, the MNA assessments would consist primarily of an assessment of plume stability. The Five Year Review, therefore, focuses on plume stability as the main, but not sole, criterion in assessing the success of MNA.

In the list above, LF006 and DP039 are the only sites at which MNA was selected as the interim remedy. For the remainder of the sites, a Natural Attenuation Summary Report will be prepared in the future, that will make recommendations whether MNA should be selected as a final remedy at the sites. The Natural Attenuation Summary Report will be prepared in accordance with the NAAP.

MNA assessments are underway in portions of plumes that are also undergoing GET. These plumes include FT004, SD031, LF007C, SD033, SD037, and DP039. In these plumes, the higher concentration areas are undergoing GET for the purposes of Source Control and / or Migration Control and the lower concentration areas (i.e., hydraulically downgradient of the GET system) are under assessment to determine if MNA can provide effective Migration Control. However, until the GET component of the interim remedy is completed and the extraction wells turned off, the MNA component cannot be fully evaluated because migration of the upgradient plume into the MNA assessment plume area may result in increased contaminant concentrations.

MNA appears successful at stabilizing the LF006, LF007B, and LF007D plumes. MNA, in conjunction with GET, appears successful at stabilizing the FT004 and SD031 plumes. At other MNA sizes, more data are needed before conclusions may be drawn. At one site, LF007C, MNA has not been successful. Because contamination is migrating offbase at this site, MNA has been replaced with GET.

Site Consolidation

Travis AFB has constructed multiple groundwater IRAs to achieve the Source Control, Migration Control, and Offbase Remediation interim objectives. Both IRODs prescribe site-specific groundwater IRAs for the applicable IRP sites. Historically, these IRAs have been described in terms of the actions taken at the individual sites and, in some cases, at collections of sites. However, since issuance of the *LTO Strategic Plan*, a more appropriate strategy has been employed by consolidating **site-specific** IRAs with common key components into **regional** IRAs (CH2M HILL, 2001). The primary objective of this holistic grouping is to reduce costs by avoiding redundancies in the operation and documentation of sites with common components (e.g., a shared treatment plant).

The primary criteria for grouping site-specific IRAs into consolidated, regional IRAs include the following:

- Commingled groundwater contaminant plumes
- Shared groundwater conveyance and treatment systems
- Hydraulic interactions between site-specific groundwater extraction systems
- Consolidation consistent with the IRA objective(s) provided in the applicable IROD

Based on these criteria, the strategic groupings of individual contaminated groundwater sites into consolidated IRAs are as follows:

- **North IRA** – IRP Sites FT004, SD031, LF006, LF007B, LF007C, and LF007D
- **South IRA** – IRP Sites SS030, SS029, ST032, southern portion of SS016, FT005-onbase, and FT005-offbase
- **Central IRA** – northern portion of IRP Site SS016
- **West IRA** – IRP Sites SS014, SS015, SD033, SD034, SS035, SD036, SD037, SS041, SD043, DP039, and LF008

Additionally, three petroleum-only contaminated (POCO) sites are grouped into IRAs for future Risk-based Corrective Actions (RBCA) in accordance with the *POCO Sites Work Plan* (IT Corporation, 1996). These POCO IRAs are not included in an IROD, and are therefore not evaluated as part of this five-year review. The POCO sites are as follows:

- **ST018 RBCA**
- **ST027 RBCA**
- **ST028 RBCA**

Additional information about the IRA groupings is provided in Table ES-1. The locations of the consolidated, regional IRAs are shown on Figure ES-1.

Performance Summary

The primary purpose of this five-year review is to document that the groundwater IRAs constructed at Travis AFB are protective of human health and the environment and are functioning as designed. Therefore, the following basic information is summarized in Table ES-1:

- The IRA objective specified for each site in the applicable *Groundwater IROD for the NEWIOU* or *Groundwater IROD for the WABOU*
  - Source Control
  - Migration Control
  - Offbase Remediation
- A statement of whether the interim remedy is meeting the IRA objective(s)
- A statement of whether the interim remedy is, or is expected to be, protective
- Deficiencies identified during the review
- Optimization opportunities that may improve the performance of a remedy

Protectiveness Statement

Groundwater IRAs at Travis AFB are completed and fully operational or are planned for completion in 2003. The status of the IRA at each IRP site is summarized in Table ES-1. At each of the groundwater sites at Travis AFB, interim remedies are, or are expected to be, protective of human health and the environment. In the interim, exposure pathways that could result in unacceptable risk are being controlled.

The following three questions are incorporated into the technical review of remedy performance at each site:

1. Is the remedy functioning as intended by the IROD?
2. Are the exposure assumptions, toxicity, data, cleanup levels, and remedial action objectives still valid?
3. Has any other information come to light that could call into question the protectiveness of the remedy?

The answers to these questions are "Yes," "Yes," and "No," respectively, for all of the groundwater sites at Travis AFB.

Fully Implemented Interim Remedial Actions

Each of the fully constructed and operating groundwater IRAs at Travis AFB is meeting the objectives specified in the applicable *Groundwater IROD for the NEWIOU* or *Groundwater IROD for the WABOU*. IRA and IRP sites operating as intended and deemed protective of human health and the environment are as follows:

- **North IRA** – IRP Sites FT004, SD031, LF006, LF007B, and LF007D
- **South IRA** – IRP Sites SS030, SS029, ST032, southern portion of SS016, and FT005-onbase
- **Central IRA** – northern portion of IRP Site SS016
- **West IRA** – IRP Sites SS014, SD033, SD034, SS035, SD036, SD037, SS041, SD043, and LF008

Pending Interim Remedial Actions

Through 2002, groundwater IRAs have not yet been fully implemented at several IRP sites identified in the applicable *Groundwater IROD for the NEWIOU* or *Groundwater IROD for the WABOU*. Therefore, these IRAs cannot be fully evaluated in this first five-year review. When these IRAs are fully constructed and operating normally, they are expected to be meet IRA objectives and be protective of human health and the environment. These pending IRAs include the following:

- **North IRA** – IRP Site LF007C: Implementation of a GET system planned for summer 2003. Construction of the offbase component of the system dependent on obtaining an easement for access onto privately owned property.
- **South IRA** – IRP Site FT005-offbase: Implementation of a GET system planned for summer 2003.
- **Central IRA –** IRP Site SS016: the Air Force will continue to monitor to make sure that contamination exceeding 1,000 micrograms per liter is being captured as part of Source Control at this site. The Air Force will also continue to monitor the movement of lower-concentration portions of the plume southward under the runway to ensure that this

contamination is captured by the extraction systems at Sites FT005 or SS029. If necessary, additional actions may be programmed to address control of contamination south of the runway.

- **West IRA –**
  - IRP Site SS015: ongoing enhanced biodegradation treatability study.
  - IRP Site DP039: ongoing phyto-remediation treatability study. Phase 2 of the remedial actions specified in the *Groundwater IROD for the WABOU* will be implemented if necessary.

Additionally, RBCAs are pending at the ST018, ST027, and ST028 POCO sites in accordance with the *POCO Sites Work Plan.*

Next Five-Year Review

The interim actions at Travis AFB will continue for another five years before considering a ROD, for the following reasons:

1. This review was triggered by the initiation of the first IRA following the signing of the *Groundwater IROD for the NEWIOU*. However, at most sites, groundwater actions have been underway for fewer than five years. At some sites (e.g., FT005-offbase and LF007C), IRAs have not yet been completely constructed. More time is needed to observe the impact of these actions on groundwater contamination at Travis AFB.
2. MNA has been selected as an interim remedy only at LF006 and DP039. At other sites, MNA is being assessed during the interim period. The key question addressed in the assessment at these sites is whether the plumes are continuing to migrate or are stable. Not enough time has passed to answer this question at most sites.
3. The selection of final cleanup levels is a complex question that involves issues of risk and technical and economical feasibility. More data are needed to resolve these questions.
4. Groundwater remediation may be optimized at many sites, as noted in this document. The IRODs are flexible enough to permit this optimization, and optimization should be an ongoing process. Another five years will allow time to observe the effects of optimization.
5. Treatability studies are underway at several sites (e.g., SS015 and DP039). These studies need to be completed and evaluated before IRAs (or remedial actions) can be implemented.

The second five-year review of groundwater IRAs at Travis AFB is currently scheduled for 2008. It is anticipated that after the second five-year review there will be sufficient data to support the development of the Final Basewide Groundwater ROD. This ROD will be prepared by the Air Force in cooperation with EPA, SFBRWQCB, and DTSC, and will stipulate the final groundwater cleanup concentrations and remedial actions at Travis AFB.

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TABLE ES-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	Site	Source Control	Migration Control	Offbase Remediation	MNA[b]	MNA Assessment[c]	Are Interim Remedial Action Objectives Met?	Is Interim Remedy Protective?[d]	Deficiencies	Optimization Opportunities/Further Actions	Comments
North IRA	FT004	Ö				Ö[e]	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass.	GET and MNA are considered successful at FT004 and SD031.
	SD031	Ö				Ö[e]	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Install additional monitoring wells southeast of EW567x31. Expand soil vapor treatment capacity.	
	LF006				Ö		Yes	Yes	None	Continue natural attenuation assessment monitoring.	MNA is successful at LF006.
	LF007B					Ö	Yes	Yes	None	Continue natural attenuation assessment monitoring.	MNA is successful at LF007B.
	LF007C		Ö	Ö		Ö[f]	No	Yes	LF007C IRA construction not complete. Onbase extraction wells and performance monitoring wells installed during fall/winter 2002, but system is not yet operational, and construction of offbase monitoring wells has not begun.	Construct remaining extraction system components and conveyance pipeline to the North Groundwater Treatment Plant in summer 2003. Conduct offbase plume delineation and performance monitoring well installations in summer 2003. Obtain easement onto the privately owned offbase property prior to beginning construction.	MNA has not been successful at LF007C; GET will replace MNA at this site.
	LF007D					Ö	Yes	Yes	None	Continue natural attenuation assessment monitoring.	MNA is successful at LF007D.
South IRA	SS030	Ö	Ö	Ö			Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Install additional monitoring wells to monitor performance of new extraction wells. Assess in situ technologies to reduce contaminant mass in source area.	Contaminant plume mostly underlies offbase private property. GET has protected drinking water supply in this area.

TABLE ES-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	Site	Source Control	Migration Control	Offbase Remediation	MNA[b]	MNA Assessment[c]	Are Interim Remedial Action Objectives Met?	Is Interim Remedy Protective?[d]	Deficiencies	Optimization Opportunities/Further Actions	Comments
	SS029		Ö				Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas or to prevent migration from SS016. Install additional monitoring wells to monitor performance of new extraction wells. Assess in situ technologies to reduce contaminant mass in source area.	SS029 Migration Control GET system constructed to prevent movement of contamination to nearby offbase private property, and is successful.
	ST032	Ö	Ö[d]			--[g]	Yes	Yes	None	Continue LTO of SS029 GET system and SBBGWTP. Continue ongoing assessment of free product. Continue ongoing remedial process optimization.	ST032 Source Control IRA for removal of floating jet fuel in one site monitoring well. SS029 Migration Control GET IRA hydraulically captures dissolved portion of ST032 plume. ST032 Migration Control IRA not required because the commingled OSA/TARA/Southern SS016/ST032 plume is hydraulically captured by SS029 Migration Control GET IRA.
	Southern SS016		Ö			--[g]	Yes	Yes	None	Continue LTO of SS029 GET system and SBBGWTP. Install additional extractions wells to stop southerly migration.	Southern SS016 natural attenuation assessment not implemented and is no longer applicable because SS029 Migration Control GET IRA hydraulically captures the commingled Southern SS016/ST032 plume.
	FT005-onbase		Ö				Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells.	
	FT005-offbase			Ö			No	Yes	FT005-offbase IRA construction not complete. Onbase extraction wells and performance monitoring wells have been installed, but system is not yet fully operational, and construction of additional offbase wells is pending.	Construct remaining extraction system components and conveyance pipeline to the SBBGWTP in summer 2003. Conduct offbase plume delineation and performance monitoring well installations south of Creed Road.	Completion of FT005-offbase plume delineation and installation of extrac-tion system and performance moni-toring wells planned for summer 2003.
Central IRA	Northern SS016	Ö					Yes	Yes	None	Evaluate replacement of the thermal oxidation system with vapor-phase granular activated carbon. Evaluate replacement of ultraviolet oxidation and liquid-phase granular activated carbon with air stripper. Consider in situ technologies in source areas to reduce mass.	OSA and TARA source area plumes[h] comprise the Central IRA. GET appears successful at achieving Source Control, although ongoing monitoring is needed.
West IRA	SS014[h]	Ö	Ö			Ö[e]	Yes	Yes	None	Continue LTO of free-product removal action.	POCO site. Source Control at Site 1 for removal of floating jet fuel.

TABLE ES-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	Site	Source Control	Migration Control	Offbase Remediation	MNA[b]	MNA Assessment[c]	Are Interim Remedial Action Objectives Met?	Is Interim Remedy Protective?[d]	Deficiencies	Optimization Opportunities/Further Actions	Comments
	SD033[i]		Ö			Ö	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass. Continue natural attenuation assessment monitoring.	SD033 plume is commingled with SD037 plume. GET and MNA appear successful at these sites, but ongoing monitoring is needed for confirmation.
	SD034[j]	Ö	Ö				Yes	Yes	None	Continue LTO of active skimmers.	Source Control for removal and hydraulic containment of Stoddard solvent. Floating product Migration Control for dissolved volatile organic compound plume.
	SS035[k]		Ö			--[g]	Yes	Yes	None	Continue LTO of GET system.	Natural attenuation assessment discontinued and no longer applicable because plume is hydraulically captured by SD037 Migration Control GET IRA.
	SD036[l]	Ö	Ö			--[g]	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass.	SD036 plume is commingled with SD037 plume.
	SD037[m]	Ö	Ö			Ö	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass. Continue natural attenuation assessment monitoring. Evaluate existing site data to confirm that extent of contamination is fully characterized.	SD037 plume is commingled with the SD033 and SD036 plumes.
	SS041[n]		Ö				Yes	Yes	None	Continue LTO of GET system.	
	SD043[o]		Ö				Yes	Yes	None	Continue LTO GET system.	

TABLE ES-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	**Site**	**Source Control**	**Migration Control**	**Offbase Remediation**	**MNA[b]**	**MNA Assessment[c]**	**Are Interim Remedial Action Objectives Met?**	**Is Interim Remedy Protective?[d]**	**Deficiencies**	**Optimization Opportunities/Further Actions**	**Comments**
	SS015					--	No	Yes		Investigate source, nature, and extent of contamination. Assess whether MNA is still a viable option for SS015.	Ongoing treatability study of enhanced biodegradation. New facility construction at site is planned for 2003.
	DP039	Ö	--[p]		Ö		No	Yes	None – downgradient extraction will capture any migrating contamination. The migration is currently confined to one portion of the site.	Complete phytoremediation treatability study. Assess in situ remediation in source area to reduce mass (electron donor and emulsified ZVI etc). Assess installation of additional extraction wells as appropriate. Evaluate existing site data to confirm that extent of contamination is fully characterized.	Ongoing phytoremediation treatability Study and MNA assessment. More data needed. Completed treatability studies have included reactive wall and multi-phase extraction.
	LF008		Ö				Yes	Yes	None	Continue LTO of LF008 GET system.	Noncontiguous, single-site plume.
ST018 RBCA	ST018						Not evaluated	Not evaluated	Not evaluated	Not evaluated	POCO site – not specified in IROD – pending RBCA.
ST027 RBCA	ST027						Not evaluated	Not evaluated	Not evaluated	Not evaluated	POCO site – not specified in IROD – pending RBCA.
ST028 RBCA	ST028						Not evaluated	Not evaluated	Not evaluated	Not evaluated	POCO site – not specified in IROD – pending RBCA.

[a]IRA objective specified in the Groundwater IRODs for the NEWIOU and WABOU.

[b]MNA was selected in the IROD.

[c]MNA is being assessed during the interim period.

[d]Detailed statements of protectiveness are provided in site-specific sections.

[e]IRA not specified in the *Groundwater IROD for the NEWIOU*, but implemented by the Air Force to address entirety of commingled plume.

[f]Assessment of MNA will continue in the interior portion of the plume.

[g]Assessment of MNA not implemented or has been discontinued because the site plume is hydraulically captured by an adjacent GET system.

[h]POCOS Site SS014 comprises five noncontiguous sites, including Sites 1, 2, 3, 4, and 5. Only Site 1 has a Source Control objective (floating jet fuel).

[i]IPR Site SD033 comprises five noncontiguous sites: Facility 810, Facility 1917, Storm Sewer System II, the South Gate area, and the West Branch of Union Creek.

[j]IRP Site SD034 is associated with Facility 811.

[k]IRP Site SS035 is associated with Facilities 818 and 819.

[l]IRP Site SD036 is associated with Facilities 872, 873, and 876.

[m]IRP Site SD037 is associated with the Sanitary Sewer System; Facilities 837, 838, 919, 977, 981; the Area G Ramp; and the Ragsdale/V Street area.

[n]IRP Site SS041 is associated with Facility 905.

[o]IRP Site SD043 is associated with Facility 916.

[p]Deferred – Migration Control not implemented pending evaluation of MNA and treatability studies.

Notes:

SBBGWTP = South Base Boundary Groundwater Treatment Plant
TARA = Tower Area Removal Action

SECTION 1.0

Introduction

This document comprises the *Groundwater Five-Year Review Report* for groundwater interim remedial actions (IRA) being conducted at Travis Air Force Base (Travis AFB or Base), California. The location of Travis AFB is shown on Figure 1-1. (All figures for this *Groundwater Five-Year Review Report* are located at the end of the section or subsection in which they are referenced.) This document reports the first five-year review of groundwater remedies at Travis AFB. The triggering action for this review is the implementation of the first IRA following the signing of the final *Groundwater Interim Record of Decision (IROD) for the North, East, West Industrial Operable Unit (NEWIOU)* (Travis AFB, 1997). That action was the startup of the South Base Boundary Groundwater Treatment Plant (SBBGWTP) in July 1998.

1.1 Purpose and Scope of the Five-Year Review

The primary purpose of the five-year review is to ensure that the interim groundwater remedies constructed at Travis AFB are protective of human health and the environment and are functioning as designed. Specifically, the five-year review provides the following fundamental information:

- States whether the interim remedy is, or is expected to be, protective. The protectiveness of the remedy is determined by answering three key questions:
  - Is the remedy functioning as intended by the decision documents?
  - Are the assumptions used at the time of remedy selection still valid?
  - Has any other information come to light that could call into question the protectiveness of the remedy?
- Documents any deficiencies identified during the review
- Recommends specific actions to ensure that a remedy will be, or will continue to be, effective

The Air Force and regulatory agencies agreed that an IROD was the best way to proceed at Travis AFB, because using interim actions allowed the remediation to begin quickly to reduce contamination and risk. The Final *Groundwater IROD for the NEWIOU* states on page 91 that “the Air Force has developed interim remedial goals (IRGs) to evaluate the performance of implemented remedial alternatives during the five-year interim period” (Travis AFB, 1997). The toxicity values for several groundwater contaminants, including trichloroethylene (TCE), chloroform, and vinyl chloride, have changed since the IROD, and ultimately may lead to a lowering of the Maximum Contaminant Levels (MCL) established in the National Primary Drinking Water Standards (Title 40 CFR Part 141). These MCLs have not changed during the period of interim remediation. For the pending Basewide Groundwater Record of Decision (ROD), final groundwater cleanup levels will be developed with consideration of changes to MCLs (e.g., resulting from changed contaminant toxicity values) and Applicable, Relevant, and Appropriate Requirements (ARAR). The final cleanup levels will also take into account soil gas contamination and potential human health risks caused by exposure to soil gas diffusing into buildings.

The evaluations within this *Groundwater Five-Year Review Report* are based on compliance with the IRODs and use interim remediation goals (IRG) to assess the performance of interim groundwater remedies. The ARARs used in the IRODs are still valid. In addition to these criteria, the protectiveness of each interim groundwater remedy is determined by answering three key questions:

- Question A – Is the remedy functioning as intended by the decision documents?
- Question B – Are the assumptions used at the time of remedy selection still valid?
- Question C – Has any other information come to light that could call into question the protectiveness of the remedy?

The answers to these questions are provided in subsequent sections of this *Groundwater Five-Year Review report*.

Soil gas migration from plumes to buildings has become an area of increased concern by the U.S. Environmental Protection Agency (EPA) since the IRODs were signed. Prior to development of the Basewide Groundwater ROD, the Air Force will evaluate this potential pathway using the risk assessment protocol and ARARs agreed upon at that time.

1.1.1 Authority and Guidance

This *Groundwater Five-Year Review Report* was prepared in accordance with the EPA *Comprehensive Five-Year Review Guidance* (EPA, 2001). This review is required by statute and is conducted in accordance with the following authorities and guidance:

- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, 42 USC § 9621(c)
- National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR 300.430(f)(4)(ii)
- Executive Order 12580: Superfund Implementation (May 1993)
- *Federal Facilities Agreement* for Travis AFB (September 1990)

Based on the *Comprehensive Five-Year Review Guidance*, this review is considered to be a **policy** review. The Travis AFB IRAs are post-Superfund Amendments and Reauthorization Act actions that, upon completion, will not leave hazardous substances, pollutants, or contaminants onsite above levels that allow for unlimited use and unrestricted exposure. However, the actions will require five or more years to complete.

1.1.2 Scope of the Groundwater Five-Year Review Report

The scope of the *Groundwater Five-Year Review Report* includes the groundwater IRAs at the Installation Restoration Program (IRP) sites addressed by the two existing Travis AFB groundwater IRODs. These IRODs document the selection of IRAs for contaminated groundwater IRP sites at Travis AFB. The two IRODs include the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997) and the *Groundwater IROD for the West/Annexes/Basewide Operable Unit (WABOU)* (Travis AFB, 1999). More complete descriptions of the IRP sites and areas of groundwater contamination addressed by the two IRODs are provided in subsequent sections of this report.

1.1.3 Groundwater Five-Year Review Report Process

This *Groundwater Five-Year Review Report* was prepared in accordance with the U.S. EPA *Comprehensive Five-Year Review Guidance* (U.S. EPA, 2001). Numerous sources of information have been used in the review process. The key works cited are as follows:

- *Travis AFB Long-term Operation (LTO) Strategic Plan* (CH2M HILL, 2001a)
- *Groundwater Sampling and Analysis Program (GSAP), 2001-2002 Annual Report* (CH2M HILL, 2003a)
- *Groundwater IROD for the NEWIOU* (Travis AFB, 1997)
- *Groundwater IROD for the WABOU* (Travis AFB, 1999)

Additional information is derived from the routine operation and maintenance (O&M) reports for the three existing groundwater treatment plants at Travis AFB. These three facilities are as follows:

- The Central Groundwater Treatment Plant (CGWTP), which includes the West Treatment and Transfer Plant (WTTP)
- The North Groundwater Treatment Plant (NGWTP)
- The SBBGWTP

1.1.3.1 Regulatory Agency Involvement

Travis AFB is the lead agency for the groundwater remediation being evaluated in this first five-year review. The San Francisco Bay Regional Water Quality Control Board (RWQCB), U.S. EPA Region IX, and the California Department of Toxic Substances Control have participated in this review and provided regulatory agency oversight of the groundwater interim remedies implemented at Travis AFB.

As the lead federal agency, the Air Force is required to perform the five-year reviews for Travis AFB under CERCLA 104, 120 under Executive Order 12580. EPA is required to assure that the review adequately addresses the protectiveness of the remedies. The Air Force selected a contractor (CH2M HILL) to support Travis AFB in the preparation of the five-year review. CH2M HILL has provided historical support to Travis AFB performing remedial investigations (RI), feasibility studies (FS), remedial designs, remedial actions, groundwater monitoring, and O&M of treatment facilities.

1.1.3.2 Restoration Advisory Board

The Restoration Advisory Board (RAB) provides a means for Travis AFB to communicate the status and effectiveness of the interim groundwater remedies with the community.

Restoration Advisory Board members have reviewed documents and provided comments on plans related to groundwater cleanup activities, including the five-year review. Periodic reports on the progress of the five-year review process have been provided to the Restoration Advisory Board during scheduled meetings.

1.1.3.3 Community Involvement

Travis AFB communicates with the community via the RAB; periodic reports published in the quarterly environmental cleanup program newsletter *Guardian*, and public notices. A copy of the Draft Five-Year Review was provided to the RAB for review. Public notices were published in both the *Vacaville Reporter* and *Fairfield Daily Republic* in December 2002, and the Travis AFB *Tailwind* in January 2003. Additional public notices will be provided after the Five-Year Review is completed, and a copy of the final report will be placed in the Vacaville Public Library-1020 Ulatis Drive, Vacaville, California 95688 (707/449-6290).

1.1.3.4 Schedule

The first five-year review is being conducted from January through June 2003. Submittal of the final Travis AFB *Groundwater Five-Year Review Report* is scheduled for 27 June 2003.

1.2 Groundwater Five-Year Review Report Organization

The following list provides a brief summary of the organization and content of this *Groundwater Five-Year Review Report*:

- **Section 1.0 – Introduction:** Describes the subject, purpose, scope, and contents of this *Groundwater Five-Year Review Report*.
- **Section 2.0 – Background:** Discusses the physical, administrative, regulatory, and other background information related to Travis AFB and the five-year review.
- **Section 3.0 – North IRA Area:** Provides descriptions of IRAs at sites within the North IRA area, status, groundwater monitoring, a cost evaluation of the remedies, and a discussion of the opportunities for optimization.
- **Section 4.0 – South IRA Area:** Provides descriptions of IRAs at sites within the South IRA area, status, groundwater monitoring, a cost evaluation of the remedies, and a discussion of the opportunities for optimization.
- **Section 5.0 – Central IRA Area:** Provides descriptions of IRAs at sites within the Central IRA area, status, groundwater monitoring, a cost evaluation of the remedies, and a discussion of the opportunities for optimization.
- **Section 6.0 – West IRA Area:** Provides descriptions of IRAs at sites within the West IRA area, status, groundwater monitoring, a cost evaluation of the remedies, and a discussion of the opportunities for optimization.
- **Section 7.0 – Summary:** Summarizes the findings of the five-year review process.
- **Appendices**
  - Appendix A – Groundwater Modeling
  - Appendix B – Response to Comments

1.3 References

CH2M HILL. 2003a. Final *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report*. Volumes 1 and 2. Installation Restoration Program. Travis AFB, California. 7 February.

CH2M HILL. 2001a. Final *Long-term Operation Strategic Plan, Version 1*. Installation Restoration Program. Travis AFB, California. 10 December.

Travis AFB. 1999. Final *Groundwater Interim Record of Decision for the West/Annexes/Basewide Operable Unit*. Installation Restoration Program. Travis AFB, California. 24 June.

Travis AFB. 1997. Final *Groundwater Interim Record of Decision for the North, East, and West Industrial Operable Unit*. Installation Restoration Program. Travis AFB, California. December.

Travis AFB. 1990. *Federal Facilities Agreement*. September.

U.S. Environmental Protection Agency (U.S. EPA). 2001. *Comprehensive Five-Year Review Guidance*. Office of Solid Waste and Emergency Response Directive 9355.7-03B-P. EPA 540R-01-007. June.

Figure
1-1 Travis AFB Location
(8-1/2 x 11 landscape, b&w)

SECTION 2.0

Background

This section provides physical, administrative, regulatory, and other background information related to the ongoing interim remediation of contaminated groundwater at Travis AFB.

2.1 Physical Setting

Travis AFB is located midway between San Francisco and Sacramento, California, on low-lying ground within 1 mile of Suisun Marsh, an estuary of San Francisco Bay. It is located 3 miles east of downtown Fairfield in Solano County. The Base occupies over 6,000 acres and maintains ownership of, or administrative control over, several properties at offbase locations. Facilities include two major runways, associated taxiways and aircraft parking aprons, numerous hangars, buildings, shops, offices, freight handling and storage areas, and maintenance facilities. Approximately 17,000 military and civilian personnel are present daily on the Base.

Travis AFB is part of Air Mobility Command and is host to the 60th Air Mobility Wing and other units. The 60th Air Mobility Wing operates C-5 Galaxy cargo aircraft and KC-10 Extender refueling aircraft. The primary missions of Travis AFB, since its establishment in 1943, have been strategic reconnaissance and airlift of freight and troops.

2.1.1 Geology

Travis AFB is located on the western edge of the Sacramento Valley segment of the Great Valley geomorphic province. The Great Valley province is a southeast-trending, sediment-filled synclinal basin. Just west of Travis AFB lies the Coast Range geomorphic province comprising folded and uplifted bedrock (Thomasson et al., 1960; Olmstead and Davis, 1961).

The geomorphology of the area is characterized by gently sloping alluvial plains and fans overlying Tertiary sedimentary rock. Coalescing, low-relief fans have been deposited by streams (e.g., Union Creek and Laurel Creek) migrating across the Base over time. The majority of alluvium, referred to as "Older Alluvium," was deposited during the Pleistocene age prior to the last glaciation. Drainages were incised in Older Alluvium during the last glacial period in response to dropping sea levels. Incised channels were filled with alluvium, referred to as "Younger Alluvium," over the past 11,000 years to produce a complex hydrogeologic environment comprising discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay. Sand lenses are typically elongated parallel to (former) streams, trending south-southeast across the Base. Where present, lenses of sand vary in continuity and thickness. Alluvium ranges in thickness from 0 to approximately 70 feet in the area. The thickness of alluvium generally increases to the southeast. West of Travis AFB, the thickness of alluvium increases to over 200 feet (Thomasson et al., 1960). The distribution of alluvium and shallow sedimentary rock at Travis AFB is shown on Figures 2-1 and 2-2.

The Base is located on a southeasterly plunging anticline in consolidated and semi-consolidated sedimentary beds. The following sedimentary rocks have been identified in the area (from oldest to youngest): Domengine Sandstone, Nortonville Shale, Markley Sandstone, Neroly Sandstone, and Tehama Formation.

Erosion of less resistant bedrock units (e.g., Nortonville Shale and Neroly Sandstone) by ancient streams led to the formation of channels and depressions in the bedrock surface that were filled with Older and Younger Alluvium. Tehama Formation and Markley Sandstone outcrop at the flanks of the anticline in the western and eastern portions of the Base, respectively (Figures 2-2 and A-1 [see Appendix A]). Domengine Sandstone outcrops north of the Base housing area and at the Consolidated Support Center (location of the old Base hospital). Outcrop is mantled by colluvium and forms low hills and ridges at the Base (50 to 100 feet in relief). Where colluvium interfingers with alluvium, the two lithologies are indistinguishable in the field.

2.1.2 Groundwater

Regionally, Travis AFB is located along the eastern edge of the Fairfield-Suisun Hydrologic Basin adjacent to the Sacramento Valley segment of the Central Valley province. The primary water-bearing deposits in the area are Older and Younger Alluvium. Within the alluvium, discontinuous lenses of sand and silty sand are the highest permeability units, elongated parallel to (former) streams and trending south-southeast in most locations. Alluvium varies in thickness from a few feet to approximately 70 feet where present, and is saturated to within 10 to 20 feet of the land surface. The depth of alluvium has been estimated from drilling. In the western part of the Base, wells penetrating the full thickness of alluvium are sparse, and the depth to bedrock is poorly understood.

Groundwater generally flows from north to south across the Base from the foot of the Vaca Mountains to Luco and Hill Sloughs through the alluvium (Figures 2-3 and 2-4). Flow is primarily lateral. On a local scale, groundwater tends to flow from areas of elevated bedrock (outcrop) toward channels of higher transmissivity alluvium and south to southeast through the latter.

Groundwater is unconfined or semiconfined within the alluvium (depending on location). Infiltration of precipitation, runoff, and irrigation waters; leakage from streams; and lateral flow from the north and northwest recharges alluvial sediments. Groundwater is discharged from alluvium as evapotranspiration (ET), leakage to streams, losses to sanitary and storm sewers, pumping at extraction wells, and flow to Luco and Hill Sloughs. Sections 3.0 through 6.0 describe the configuration of groundwater flow in detail.

2.2 Chronology of Key Events

As a result of past waste management and disposal practices, groundwater at Travis AFB is contaminated at multiple locations. Travis AFB is implementing IRAs to address this contamination in accordance with CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan, the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997) and the *Groundwater IROD for the WABOU* (Travis AFB, 1999). Figure 2-5 graphically depicts key administrative milestones related to the Travis AFB environmental management program.

Also, a brief summary of the key events leading to the interim groundwater remedies that have been implemented at the Base through 2002 follows.

In 1983, the Air Force initiated the IRP to investigate the nature and extent of hazardous waste releases to the environment. On the basis of IRP data evaluated by U.S. EPA, Travis AFB was placed on the National Priorities List on 21 November 1989 (54 Federal Register 48187). Approximately 1 year later, on 27 September 1990, the Air Force, U.S. EPA, California Department of Toxic Substances Control, and the San Francisco Bay RWQCB negotiated and signed the *Federal Facilities Agreement* that established the framework and schedule for environmental cleanup at Travis AFB.

Under the original *Federal Facilities Agreement*, Travis AFB was treated as a single entity with one associated comprehensive cleanup schedule. In May 1993, the *Federal Facilities Agreement* was amended to divide the Base into four operable units to facilitate the overall cleanup program. The operable unit boundaries are shown on Figure 2-6. The four operable units include the following:

- East Industrial Operable Unit (EIOU)
- West Industrial Operable Unit (WIOU)
- North Operable Unit (NOU)
- WABOU

Between approximately 1983 and 1994, early IRP investigations, data gathering, and work planning efforts were conducted to preliminarily assess the nature of environmental contamination at Travis AFB. After these efforts were completed, more focused CERCLA RI were performed within each of the Travis AFB operable units between 1994 and 1996. Following the RIs, in October 1995, the EIOU, WIOU, and NOU were combined into the NEWIOU. An FS was then completed for the NEWIOU, and IRA alternatives were developed, screened, and evaluated for each site (Radian Corporation, 1996a).

The FS was followed by the NEWIOU Groundwater Proposed Plan, which proposed the preferred IRA alternative for each NEWIOU groundwater site (Radian Corporation, 1996b). Subsequently, the IRAs for each site were formally selected in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). Since that time, interim remedial designs and remedial actions have been completed or are underway at each NEWIOU IRP site identified in the IROD.

The sequence of events for IRP sites within the WABOU is similar to that for the NEWIOU. After some preliminary IRP investigations and a planning phase, the *WABOU RI Report* was completed in May 1997 (CH2M HILL, 1997). The subsequent *WABOU FS Report* was finalized in April 1998 (CH2M HILL, 1998a). A *Groundwater Proposed Plan for the WABOU* had also been developed and was published in November 1997. The final *Groundwater IROD for the WABOU* was completed in June 1999 (Travis AFB, 1999). Since that time, interim remedial design and remedial actions have been completed or are underway at each WABOU IRP site identified in the IROD.

Remediation of both NEWIOU and WABOU contaminated groundwater sites is conducted under IRODs, as opposed to final ROD. These interim actions were designed and constructed to quickly begin remediation of groundwater contamination, reduce the levels of contamination and potential risk, and collect some of the data necessary for the selection of final cleanup levels and technically and economically feasible long-term actions. The use of IRODs allowed IRAs to proceed without having final designated cleanup levels, as will be required for the final Basewide Groundwater ROD. The interim actions taken under the NEWIOU and WABOU groundwater IRODs use IRG and Interim Cleanup Goals, respectively, as performance objectives. These IRGs and Interim Cleanup Goals are not legally enforceable standards, but are simply goals used during the period of interim LTO of the IRAs.

Following construction and operation of the majority of groundwater IRAs within the NEWIOU and WABOU, the *LTO Strategic Plan* was finalized in December 2001 (CH2M HILL, 2001a). This document addresses LTO strategies for ongoing groundwater IRAs, as well as monitoring strategies for pending sediment and surface water remedial actions at Travis AFB. This document identified significant changes to the ongoing groundwater treatment plant operations and to the GSAP. Among other things, the document implemented Remedial Process Optimization (RPO) at Travis AFB sites, and significantly optimized the GSAP (CH2M HILL, 2001a).

2.3 Contaminated Groundwater Sites

The following subsections provide brief descriptions of the contaminated groundwater sites at Travis AFB.

2.3.1 Installation Restoration Program Sites

The locations of Travis AFB IRP sites with groundwater contamination are shown on Figures 2-7 and 2-8. (Plate 1 located at the back of this document is an enlarged version of Figure 2-8.) These figures incorporate all available data from groundwater investigations conducted through 2002 to depict the distribution of groundwater contamination. The IRP site boundaries are shown in relation to the contaminant plumes. Plate 1 provides more detail on the location of sites and distribution of contamination at Travis AFB.

2.3.1.1 NEWIOU Groundwater Sites

Contaminated groundwater IRP sites within the NEWIOU include the following:

- **FT004 – Fire Training Area (FTA) 3:** Area used for fire training exercises using burning waste fuels, oils, and solvents on open ground from approximately 1953 through 1962. Historical practices resulted in groundwater contamination with chlorinated volatile organic compounds (VOC).
- **FT005 – FTA 4:** Area used for fire training exercises using burning waste fuels, oils, and solvents on open ground from approximately 1962 through 1987. Historical practices resulted in groundwater contamination with chlorinated VOCs. The contaminant plume extends onto offbase privately owned property.
- **LF006 – Landfill 1:** A general refuse landfill that used trench and cover methods from approximately 1943 through 1950. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.
- **LF007B, C, and D – Landfill 2:** A general refuse landfill that used trench and cover methods from approximately 1950 through 1970. Historical practices resulted in

groundwater contamination with chlorinated VOCs, dioxins, and polychlorinated biphenyls (PCB). The LF007C contaminant plume extends onto offbase privately owned property.

- **SS015 – Solvent Spill Area and Facilities 808, 1832, 552:** Facilities used between approximately 1964 through 1980 for solvent stripping of aircraft parts, aircraft maintenance and repair, oil / water separator (OWS) activities, and hazardous waste accumulation. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **SS016 – Oil Spill Area (OSA); Facilities 11, 13/14, 20, 42/1941; and portions of the storm sewer system:** Flightline support areas subject to oil spills, degreasing operations, leaking OWSs, equipment maintenance and repair, aircraft and vehicle maintenance, hazardous materials storage, aircraft and vehicle washing, and stormwater runoff. Most of the areas were used from the 1940s through present day. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **SS029 – Monitoring Well (MW)-329 Area:** Undeveloped land near the south Base boundary. The historical uses resulting in groundwater contamination with chlorinated VOCs are unknown.
- **SS030 – MW-269 Area:** Undeveloped land near the south Base boundary. Historical practices resulted in groundwater contamination with chlorinated VOCs. The contaminant plume extends onto offbase privately owned property.
- **SD031 – Facility 1205:** Area used for maintenance and repair of diesel generators, washrack activities, OWS activities, and aircraft maintenance from approximately 1957 through present day. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **ST032 – MW-246/MW-107 Areas:** Probable historical jet-fuel spill area. Currently, a thin, intermittently measured layer of floating jet fuel exists in only one monitoring well. Low concentrations of petroleum-fuel hydrocarbons are dissolved in the groundwater.
- **SD033 – Storm Sewer II, South Gate Area, Facilities 810 and 1917, and West Branch of Union Creek:** Support areas used for management of stormwater runoff, fuel transport, aircraft maintenance, and aircraft washing, including the use of washracks and OWSs. Historical practices resulted in groundwater contamination with chlorinated VOCs, some semivolatile organic compounds (SVOC), and petroleum-fuel hydrocarbons.
- **SD034 – Facility 811:** An active aircraft washrack facility with OWS and overflow pond. Leaks from the OWS resulted in a layer of Stoddard solvent floating on the groundwater table. The leaking OWS was replaced in 1994. Historical practices resulted in dissolved groundwater contamination with chlorinated VOCs, SVOCs, and petroleum-fuel hydrocarbons (including Stoddard solvent).
- **SS035 – Facilities 818/819:** Active facilities used for aircraft repair, painting, and washing. A washrack with OWS was constructed in 1970. Historical practices resulted in groundwater contamination with chlorinated VOCs.

- **SD036 – Facilities 872/873/876:** Facilities 872 / 873 / 876 consists of multiple-use shops, including a washrack and OWS. Current uses include paint shops, electrical shops, landscape maintenance, paint mixing, and paint accumulation. The buildings were constructed in 1953, and are still in use. Historical practices resulted in groundwater contamination with chlorinated VOCs, some SVOCs, and petroleum-fuel hydrocarbons.

- **SD037 – Sanitary Sewer System; Facilities 837/838, 919, 977, 981; Ragsdale/V Street Area; and Area G Ramp:** Support areas used for management of domestic and industrial wastewater, aircraft maintenance, heavy equipment maintenance, air cargo handling, vehicle washing, fuel transport, and waste accumulation. Operations began in the 1940s and continue through present day. Historical practices resulted in groundwater contamination with chlorinated VOCs, some SVOCs, and petroleum-fuel hydrocarbons.

2.3.1.2 WABOU Groundwater Sites

Contaminated groundwater IRP sites within the WABOU include the following:

- **LF008 – Landfill 3:** An inactive historic landfill consisting of a series of small, unlined trenches used to dispose of old pesticide containers. Historical practices resulted in groundwater contamination with organochlorine pesticides.

- **DP039 – Building 755, Travis AFB Battery and Electric Shop:** Prior to 1978, battery acid solutions and solvents were discharged from Building 755 into a sump. These historical practices resulted in contamination of the groundwater with chlorinated VOCs.

- **SS041 – Building 905, Travis AFB Entomology Shop:** Historical maintenance activities contaminated the groundwater with organochlorine pesticides.

- **SD043 – Building 916:** An emergency electric power facility. Historical practices may have resulted in a release of TCE at this site. Initially, PCB-1254 was considered a COC in groundwater here, but subsequent investigations concluded that PCBs are not a groundwater problem at SD043 (CH2M HILL, 2000c; Travis AFB, 2002).

2.3.2 Petroleum-only Contaminated Sites

The Travis AFB Petroleum-only Contaminated (POCO) Sites program manages petroleum contamination sites. The locations of POCO sites with groundwater contamination are also shown on Figure 2-7. The POCO sites include the following (note that POCO sites are not governed by IRODs, and are therefore not part of this five-year review):

- **SS014 – Jet-fuel Spill Area:** Site SS014 comprises five noncontiguous sites, or subareas, within the WIOU (i.e., Sites 1 through 5). SS014 is a POCO site, but petroleum-fuel hydrocarbons are commingled with CERCLA contamination. Currently, a thin, intermittently measured layer of floating jet fuel exists only at Site 1, within Fuel Storage Area G.

- **ST018 – North/South Gas Station:** A POCO site, historically used as a vehicle gas station. Historical spills and leakage have resulted in groundwater contamination with petroleum-fuel constituents.

- **ST027 – Facilities 1918, 1919, and 1754:** A POCO site used as a test stand area used for aircraft engine testing. Currently, only Facility 1918 is used. Historical activities have resulted in groundwater contamination with petroleum-fuel constituents.
- **ST028 – Facilities 363 and 1201:** A POCO site, Facility 363 is the former site of eleven 25,000-gallon underground fuel storage tanks. Ten of these tanks were removed in 1986, and the eleventh was removed in 1995. The tanks were used for the storage of gasoline, jet fuel, used oil, and hydraulic fluid. Facility 1201 is the in-flight kitchen. Historically, liquids stored in the underground storage tanks have leaked, or the tanks have been overfilled, resulting in groundwater contamination with petroleum-fuel constituents.

POCO sites are typically associated with surface and subsurface releases from fuel spills, piping leaks, OWSs, or underground storage tanks. The POCO Sites Program includes the removal of underground storage tanks and the remediation of POCO soil and groundwater using risk-based cleanup actions. The San Francisco Bay RWQCB is the lead oversight agency for this program, as CERCLA excludes petroleum as a CERCLA contaminant. For this reason, the POCO sites were not addressed in either of the IRODs. However, the Air Force does address petroleum contamination under CERCLA if it is commingled with CERCLA contaminants, as in the case of Site SS014 at Fuel Storage Area G.

2.4 Interim Remedial Actions

IRAs to address the groundwater contamination found at the various Travis AFB IRP sites are specified in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997) and the *Groundwater IROD for the WABOU* (Travis AFB, 1999). The following sections describe the current status of groundwater IRAs at Travis AFB.

2.4.1 NEWIOU IROD-specified Interim Remedial Actions

For the NEWIOU groundwater sites, the IRAs specified in the *Groundwater IROD for the NEWIOU* include the following:

- Alternative 2—Natural Attenuation/Monitoring (i.e., Monitored Natural Attenuation [MNA])
- Alternative 3—Extraction, Treatment, and Discharge

At most sites, the formal selection of Alternative 2—MNA, was deferred pending the completion of natural attenuation assessments to evaluate the feasibility of implementing MNA for all or part of several contaminant plumes. At the LF006 site, MNA was the selected IRA.

Alternative 3 uses groundwater extraction and treatment (GET) to hydraulically capture areas of groundwater contamination and remove contaminant mass.

2.4.2 WABOU IROD-specified Interim Remedial Actions

For the WABOU groundwater sites, the IRAs specified in the *Groundwater IROD for the WABOU* include the following:

- Alternative G3—Containment/Treatment/Discharge
- Alternative G5—Source Area and Groundwater Extraction/Treatment/MNA

Similar to the *Groundwater IROD for the NEWIOU* Alternative 3, the IRA specified in the *Groundwater IROD for the WABOU* as Alternative G3 is a GET action to prevent the migration of groundwater contamination into hydraulically downgradient areas. Under Alternative G5, a vacuum-enhanced version of GET is used to hydraulically contain and remove relatively high concentrations of VOCs from the vadose zone and groundwater at the source of contamination. The GET action is combined with a program of MNA to address the relatively lower levels of contamination at the leading edge of a plume.

2.4.3 Interim Remedial Action Objectives

The groundwater IRAs, as specified in the two IRODs, have been designed and constructed to achieve the following basic objectives:

- Source Control
- Migration Control
- Offbase Remediation

A summary of the IRA objectives for each IRP site is provided in Table 2-1. Summary descriptions of the Source Control, Migration Control, and Offbase Remediation IRA objectives are provided in the following subsections.

For the Five-Year Review, the following techniques measure the performance of interim groundwater remedies:

- Time-series plots showing changes in chemical concentrations in individual wells
- Contaminant-specific isoconcentration maps
- Influent concentrations at the groundwater treatment plants

Subsequent sections of this Five-Year Review provide time-series plots, isoconcentration maps, and treatment plant influent concentration for each IRA. Future GSAP reports will continue to provide similar time series plots and isoconcentration maps. Similarly, O&M reports prepared for the individual groundwater treatment plants will provide treatment plant influent concentrations.

2.4.3.1 Source Control

The objective of Source Control is to hydraulically contain and remove contaminant mass from the groundwater and vadose zone using GET and vapor extraction and treatment in areas where groundwater VOC concentrations are relatively high, typically greater than 1,000 micrograms per liter (µg/L). Source Control actions using GET are taken where secondary sources of VOC contamination (i.e., light nonaqueous-phase liquid or dense nonaqueous-phase liquid) are known or are reasonably thought to exist. Dissolved contaminant concentrations of approximately 3,000 µg/L are considered indicators of the possible presence of dense nonaqueous-phase liquid s (Travis AFB, 1997). However, as a conservative measure to address uncertainties in the distribution of contamination, Source Control actions are typically taken where groundwater VOC concentrations exceed 1,000 µg/L.

TABLE 2-1
Summary of Groundwater Sites and Interim Remedial Actions
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					IRA Consolidation Criteria			
IRA	**Site**	**Source Control**	**Migration Control**	**Offbase Remediation**	**MNA**	**MNA Assessment**	**Commingled Plumes**	**Shared Treatment Plant**	**Hydraulic Interactions**	**Comments**
North IRA	FT004	Ö				Ö[b]	Ö	Ö	Ö	Groundwater elevation data collected at Sites FT004 and SD031 indicate that the groundwater merges in the southern portion of these sites (see Figure 3.1-10).
	SD031	Ö				Ö[b]	Ö	Ö	Ö	
	LF006				Ö				Ö	
	LF007B					Ö			Ö	
	LF007C		Ö	Ö		--[c]		Ö	Ö	Onbase Migration Control/Offbase Remediation extraction wells and performance monitoring wells installed during fall/winter 2002. Installation of remaining extraction system components and conveyance pipeline to the NGWTP scheduled for summer 2003. Offbase plume delineation and performance monitoring well installations also planned for summer 2003 if an easement onto the privately owned offbase property is obtained.
	LF007D					Ö			Ö	
South IRA	SS030	Ö	Ö	Ö				Ö	Ö	
	SS029		Ö					Ö	Ö	
	ST032	Ö	Ö[d]			--[e]	Ö	Ö	Ö	Source Control for removal of floating jet fuel. Dissolved plume is hydraulically captured by SS029 Migration Control.
	Southern SS016		Ö			--[e]	Ö	Ö	Ö	Commingled OSA/TARA/ST032 plume is hydraulically captured by SS029 Migration Control.
	FT005-onbase		Ö					Ö	Ö	
	FT005-offbase			Ö				Ö	Ö	Completion of FT005-offbase plume delineation and installation of extraction system and performance monitoring wells planned for summer 2003.
Central IRA	Northern SS016	Ö						Ö		OSA and TARA source area plumes [d].
West IRA	SS014[f]	Ö	Ö			Ö[b]	Ö	Ö	Ö	POCO site. Source Control at Site 1 for removal of floating jet fuel.
	SD033[g]		Ö			Ö	Ö	Ö	Ö	
	SD034[h]	Ö	Ö				Ö	Ö	Ö	Source Control for removal of Stoddard solvent floating product.
	SS035[i]		Ö[b]			--[e]	Ö	Ö	Ö	Plume is hydraulically captured by SD037 Migration Control.
	SD036[j]	Ö	Ö			--[e]	Ö	Ö	Ö	
	SD037[k]	Ö	Ö			Ö	Ö	Ö	Ö	
	SS041[l]		Ö					Ö	Ö	
	SD043[m]		Ö					Ö	Ö	
	SS015					Ö[n]				Ongoing treatability study of enhanced biodegradation. New facility construction at site is planned for 2003, which will force the conclusion of the study.
	DP039	√	--		Ö			Ö		Ongoing phytoremediation treatability study within Source Control area of plume.
	LF008		Ö					Ö		Noncontiguous, single-site plume.

TABLE 2-1
Summary of Groundwater Sites and Interim Remedial Actions
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					IRA Consolidation Criteria			
IRA	Site	Source Control	Migration Control	Offbase Remediation	MNA	MNA Assessment	Commingled Plumes	Shared Treatment Plant	Hydraulic Interactions	Comments
ST018 RBCA	ST018									POCO site – Not specified in IROD – Pending RBCA[o].
ST027 RBCA	ST027									POCO site – Not specified in IROD – Pending RBCA.
ST028 RBCA	ST028									POCO site – Not specified in IROD – Pending RBCA.

[a] IRA objective specified in the Groundwater NEWIOU and WABOU IRODs.

[b] IRA not specified in the *Groundwater IROD for the NEWIOU*, but implemented by the Air Force to address entirety of commingled plume.

[c] Assessment of MNA not implemented because plume is hydraulically captured by LF007C groundwater extraction system.

[d] Tower Area Removal Action (TARA).

[e] Assessment of MNA not implemented because plume is hydraulically captured by adjacent groundwater extraction system.

[f] POCO Site SS014 comprises five noncontiguous sites, including Sites 1, 2, 3, 4, and 5. Only Site 1 has a Source Control objective (floating jet fuel).

[g] IPR Site SD033 comprises five noncontiguous sites: Facility 810, Facility 1917, Storm Sewer System II, the South Gate area, and the West Branch of Union Creek.

[h] IRP Site SD034 is associated with Facility 811.

[i] IRP Site SS035 is associated with Facilities 818 and 819.

[j] IRP Site SD036 is associated with Facilities 872, 873, and 876.

[k] IRP Site SD037 is associated with the Sanitary Sewer System; Facilities 837, 838, 919, 977, 981; the Area G Ramp; and the Ragsdale/V Street area.

[l] IRP Site SS041 is associated with Facility 905.

[m] IRP Site SD043 is associated with Facility 916.

[n] Deferred – Migration control not implemented pending evaluation of MNA and treatability studies.

[o] Risk-based Corrective Action (RBCA) in accordance with the *POCO Sites Work Plan* (IT Corporation, 1996).

Source Control actions were typically designed and constructed primarily to achieve hydraulic containment and removal of the highest concentrations of groundwater contamination. That is, to prevent VOC contaminants at concentrations of 1,000 μg/L and above from migrating to areas with concentrations below 1,000 μg/L. Additional actions, such as the installation of supplemental extraction wells, specifically for the removal of more contaminant mass, are conducted to the extent that is technically and economically feasible.

2.4.3.2 Migration Control

The Migration Control objective is typically achieved using a GET system and/or MNA. At Travis AFB, Migration Control is implemented using these two actions in combination and separately.

GET Systems. Migration Control measures are typically implemented using GET to hydraulically contain areas of contamination where groundwater concentrations are between 100 and 1,000 μg/L.

Migration Control GET systems were designed and constructed primarily to prevent VOC contaminants at concentrations between 100 and 1,000 μg/L from migrating to areas with concentrations below 100 μg/L. However, in areas where it was found to be technically and economically feasible, Migration Control GET systems were installed to hydraulically contain contamination at lower concentrations. For example, at Site SS029, located near the southern Base boundary, the GET system was designed to hydraulically contain the leading edge of the plume and prevent any offbase migration of groundwater contamination.

Contaminant mass removal is not a primary objective of GET systems installed for the purpose of Migration Control. Mass removal does occur, but GET extraction wells are typically located within the relatively lower concentration areas of contaminant plumes. Therefore, mass removal is an incidental benefit of the groundwater extraction, but not a specific objective of Migration Control.

Monitored Natural Attenuation. Another potential means of achieving the Migration Control objective is MNA. This technology relies on natural physical, chemical, and biological processes to limit the migration of a contaminant plume, or portion of a plume. Areas of groundwater with relatively low-concentration contamination hydraulically downgradient of a GET system are typically addressed by MNA at Travis AFB.

The Natural Attenuation Assessment Plan is the governing document for sites, or portions of sites, undergoing assessments of MNA (CH2M HILL, 1998b). The protocols provided in the Natural Attenuation Assessment Plan are the basis for determining if the Migration Control objective has been achieved and the contaminant plume has been stabilized through natural physical, chemical, and biological processes.

In accordance with the IRODs and Natural Attenuation Assessment Plan, multiple sites at Travis AFB are undergoing MNA assessment during the period of interim remedial action. These sites include the following:

- LF006 – formally selected for MNA in the NEWIOU Groundwater IROD
- FT004 – MNA assessment combined with GET

- SD031 – MNA assessment combined with GET
- LF007B – MNA assessment
- LF007C – MNA assessment combined with GET
- LF007D – MNA assessment
- SS014 – petroleum fuels commingled with chlorinated hydrocarbons
- SD033 – MNA assessment combined with GET
- SD037 – MNA assessment combined with GET
- SS015 – MNA assessment deferred pending enhanced biodegradation treatability study
- DP039 – MNA combined with GET, reactive wall treatability study, and phytoremediation treatability study

The listed sites initially underwent preliminary assessment of biodegradation factors as part of the preparation of Natural Attenuation Assessment Work Plans. The plans established that, on an ongoing basis, the MNA assessments would consist primarily of an assessment of plume stability. Therefore, the Five-Year Review focuses on plume stability as the main, but not sole, criterion in assessing the success of MNA.

In the list above, LF006 and DP039 are the only sites at which MNA was selected as the interim remedy. For the remainder of the sites, a Natural Attenuation Summary Report will be prepared in the future, this will make recommendations whether MNA should be selected as a final remedy at the sites. The Natural Attenuation Summary Report will be prepared in accordance with the Natural Attenuation Assessment Plan.

MNA assessments are underway in portions of plumes that are also undergoing GET. These plumes include FT004, SD031, LF007C, SD033, SD037, and DP039. In these plumes, the higher concentration areas are undergoing GET for the purposes of Source Control and/or Migration Control and the lower concentration areas (i.e., hydraulically downgradient of the GET system) are under assessment to determine if MNA can provide effective Migration Control. However, until the GET component of the interim remedy is completed and the extraction wells turned off, the MNA component cannot be fully evaluated because migration of the upgradient plume into the MNA assessment plume area may result in increased contaminant concentrations.

2.4.3.3 Offbase Remediation

The objective of Offbase Remediation is to prevent further migration of groundwater contaminants using GET to hydraulically contain and remediate the offbase portion of plumes down to the contaminant-specific IRG specified in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). All known offbase contaminant plumes originated from sites located within the NEWIOU. These sites include FT005, LF007C, and SS030.

2.4.4 Groundwater Modeling

Groundwater modeling was conducted as part of the five-year review to evaluate if the IRA objectives specified in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997) and the

Groundwater IROD for the WABOU (Travis AFB, 1999) are being met by the interim remedies that have been implemented. Groundwater flow and contaminant transport simulations are conducted to assess the performance of the GET systems currently operating and to support estimates of groundwater cleanup times.

2.4.4.1 Groundwater Flow Modeling

The Travis AFB Basewide Groundwater Flow Model is used to estimate the extent of hydraulic capture during Source Control, Migration Control, and Offbase Remediation IRAs resulting from operation of groundwater extraction wells. Additional details regarding the groundwater model are provided in Appendix A.

2.4.4.2 Fate and Transport Calculations

Fate and transport calculations were performed using the results of groundwater flow simulations and a range of assumptions concerning site conditions. The calculations provide estimates of groundwater cleanup times for groundwater plumes undergoing GET interim remediation.

2.4.5 Institutional Controls

Travis AFB currently implements institutional controls at sites with groundwater contamination through a digging permit process and general planning process. These administrative controls restrict the use of onbase groundwater. Travis AFB does not and will not use its onbase groundwater for drinking water. Existing land use restrictions also govern soil excavation and other subsurface work where workers might encounter contaminated groundwater or vapors. These subsurface activities are allowed only after environmental and worker safety control measures are in place. Travis AFB uses its digging permit program to coordinate and, when necessary, restrict contractor and Base personnel access to contaminated areas. In addition, Travis AFB will amend its General Plan to document the land use restrictions.

2.5 Site Consolidation

Travis AFB has constructed multiple groundwater IRAs to achieve the Source Control, Migration Control, and Offbase Remediation objectives specified in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997) and the *Groundwater IROD for the WABOU* (Travis AFB, 1999). Both IRODs prescribe site-specific groundwater IRAs for the applicable IRP sites. Historically, these IRAs have been described in terms of the actions taken at the individual sites and, in some cases, at collections of sites. However, since issuance of the *LTO Strategic Plan*, a more appropriate strategy has been employed by consolidating site-specific IRAs with common key components into regional IRAs (CH2M HILL, 2001a). The primary objective of this holistic grouping is to reduce costs by avoiding redundancies in the operation and documentation of sites with common components.

The primary criteria for grouping site-specific IRAs into consolidated, regional IRAs include the following:

- Commingled groundwater contaminant plumes
- Shared groundwater conveyance and treatment systems
- Hydraulic interactions between site-specific groundwater extraction systems
- Consolidation consistent with the IRA objective(s) provided in the applicable IROD

Based on these criteria, and as described in the *LTO Strategic Plan*, the strategic groupings of individual contaminated groundwater sites into consolidated IRAs are as follows:

- **North IRA –** IRP Sites FT004, SD031, LF006, LF007B, LF007C, and LF007D
- **South IRA –** IRP Sites SS030, SS029, ST032, southern portion of SS016, FT005-onbase, and FT005-offbase
- **Central IRA –** Northern portion of IRP Site SS016
- **West IRA –** IRP Sites SS014, SD033, SD034, SS035, SD036, SD037, SS041, SD043, SS015, DP039, and LF008

Additionally, three POCO sites are grouped into IRAs for future RBCAs in accordance with the *Work Plan for Petroleum-only Sites* (IT Corporation, 1996). These POCO IRAs are as follows:

- ST018 RBCA
- ST027 RBCA
- ST028 RBCA

The locations of the consolidated, regional IRAs are shown on Figure 2-8. A summary of the grouped groundwater sites, the IROD-specified IRA for each site, and a checklist evaluation of the consolidation criteria satisfied are provided in Table 2-1. Summary descriptions of these IRAs are provided in the following subsections.

2.5.1 North IRA

The North IRA comprises consolidated groundwater interim actions at NEWIOU IRP Sites FT004, SD031, LF006, LF007B, LF007C, and LF007D. Table 2-2 summarizes the main components of the North IRA.

Construction of the FT004, SD031, LF006, LF007B, and LF007D components of the IRA have been completed and are in LTO.

Construction of the onbase Migration Control / Offbase Remediation GET system at LF007C is partially complete. The onbase groundwater extraction wells and performance monitoring wells are installed, and the extraction system components (e.g., pumps) and the groundwater conveyance system to the NGWTP will be constructed in mid-2003. Offbase performance monitoring wells will be constructed in mid-2003.

Routine groundwater monitoring of sites within the North IRA is conducted under the GSAP. Routine O&M is conducted in accordance with the *NGWTP O&M Manual, Sites FT004 and SD031* (GTI, 1999).

TABLE 2-2
Summary of the North Interim Remedial Action
Groundwater Five-Year Review, Travis Air Force Base, California

Contaminant Plume	Objective [a]	Implemented IRA	Primary Components	Status and Comments
FT004 Source Area	Source Control	GET	DPE wells, performance monitoring wells, NGWTP air stripper/VGAC	IRA construction complete. FT004 and SD031 source area plumes are noncontiguous.
SD031 Source Area	Source Control	GET	DPE wells, performance monitoring wells, NGWTP air stripper/VGAC	IRA complete.
FT004/SD031[b]	MNA[c]	Groundwater monitoring	Trigger, point-of-compliance, and guard wells	IRA construction complete. Addresses portion of commingled plume that is not hydraulically captured by FT004 and SD031 Source Control extraction systems.
LF006	MNA	Groundwater monitoring	Trigger, point-of-compliance, and guard wells	IRA construction complete. LF006 plume hydraulically captured by SD031 Source Control extraction system.
LF007B	MNA[c]	Groundwater monitoring	Trigger, point-of-compliance, and guard wells	Pending onbase construction.
LF007C	Migration Control	Pending – GET	Onbase groundwater extraction wells and performance monitoring wells, NGWTP air stripper/VGAC	IRA construction partially complete. Onbase extractions wells and monitoring wells installed. Groundwater conveyance to NGWTP pending in mid-2003.
LF007C	Offbase Remediation	Pending – GET	Offbase performance monitoring wells (groundwater extraction wells located onbase)	Pending completion of construction in mid-2003. Performance monitoring wells for onbase groundwater extraction wells.
LF007D	MNA[c]	Groundwater monitoring	Trigger, point-of-compliance, and guard wells	IRA construction complete.

[a] IRA objective specified in *Groundwater IROD for the NEWIOU*.
[b] Commingled plume.
[c] MNA Assessment.

Notes:

DPE = dual-phase extraction
VGAC = vapor-phase granulated activated carbon

2.5.2 Central IRA

The Central IRA comprises groundwater IRAs at the OSA and TARA contaminant source areas within the northern portion of NEWIOU IRP Site SS016. Table 2-3 summarizes the main components of the Central IRA.

Construction of the TARA component of the IRA is complete and is currently in LTO. An expansion of the OSA IRA was completed during mid-2001 and is also in LTO.

Routine groundwater monitoring of the Central IRA is conducted under the GSAP. Routine O&M is conducted in accordance with the *CGWTP O&M Manual* (Radian International, 2002; CH2M HILL, 2000a).

TABLE 2-3
Summary of the Central Interim Remedial Action
Groundwater Five-Year Review, Travis Air Force Base, California

Contaminant Plume	Objective [a]	Implemented IRA	Primary Components	Status and Comments
Northern SS016: OSA Source Area	Source Control	GET	2-Phase® extraction well, 1 horizontal extraction well, 2 groundwater extraction wells, performance monitoring wells, vapor treatment with ThOx, groundwater treatment at CGWTP with UV/Ox/LGAC	IRA construction complete. OSA and TARA source areas are noncontiguous plumes.
Northern SS016: TARA Source Area	Source Control	GET	2 horizontal extraction wells, performance monitoring wells, groundwater treatment at CGWTP with UV/Ox/LGAC	IRA construction complete.

[a] IRA objective specified in the *Groundwater IROD for the NEWIOU*.

Notes:

ThOx = thermal oxidation
UV/Ox = ultraviolet oxidation
LGAC = liquid-phase granulated activated carbon

2.5.3 West IRA

The West IRA comprises consolidated groundwater interim actions at POCO Site SS014; NEWIOU IRP Sites SD033, SD034, SS035, SD036, SD037, SS041, and SD043; and WABOU IRP Sites LF008 and DP039. Table 2-4 summarizes the main components of the West IRA. Additionally, Tables 2-5 and 2-6 summarize the noncontiguous Site DP039 and Site LF008 components of the West IRA, respectively.

Construction of the West IRA is complete and currently in LTO.

Routine groundwater monitoring within the West IRA is conducted under the GSAP. Routine O&M is conducted in accordance with the *WTTP IRA O&M Manual – Addendum to the CGWTP O&M Manual* (CH2M HILL, 2000a).

2.5.4 South IRA

The South IRA comprises consolidated groundwater interim actions at NEWIOU IRP Sites FT005-onbase; FT005-offbase; and the southern portion of SS016, SS029, SS030, and ST032. Table 2-7 summarizes the main components of the South IRA. Construction of the southern portion of SS016, SS029, SS030, and ST032 components of the South IRA is complete and currently in LTO. The onbase component of FT005 is also complete. The offbase component of FT005 is currently planned for completion in mid-2003.

Routine groundwater monitoring of the South IRA is conducted under the GSAP. Routine O&M is conducted in accordance with the *SBBGWTP O&M Manual* (CH2M HILL, 2000b).

TABLE 2-4
Summary of the West Interim Remedial Action
Groundwater Five-Year Review, Travis Air Force Base, California

Contaminant Plume	Objective [a]	Implemented IRA	Primary Components	Status and Comments
SS014 Source Area	Source Control	GET	Free-product removal with passive skimmers	IRA construction complete. Jet-fuel floating-product removal at SS014 Site 1.
SD034 Source Area	Source Control	GET	DPE wells, performance monitoring wells, free-product removal with active skimmers, VGAC vapor treatment at WTTP, UV/Ox/LGAC groundwater treatment at CGWTP via WTTP	IRA construction complete. Stoddard solvent floating-product removal.
SD036/SD037[b] Source Area	Source Control	GET	DPE wells, performance monitoring wells, VGAC vapor treatment at WTTP, UV/Ox/LGAC groundwater treatment at CGWTP via WTTP	IRA construction complete. SD036 and SD037 source area plumes are commingled.
SS014/SD033/ SD034/SS035/ SD036/SD037[b]	Migration Control	GET	Conventional extraction wells [c], perfomance monitoring wells, VGAC vapor treatment at WTTP, UV/Ox/LGAC groundwater treatment at CGWTP via WTTP	IRA construction complete. Hydraulically captured portions of commingled plumes.
SS041	Migration Control	GET	Conventional extraction well, performance monitoring wells, UV/Ox/LGAC groundwater treatment at CGWTP via WTTP	IRA construction complete. SS041 and SD043 plumes are non-contiguous with each other and the commingled SS014/SD033/ SD034/SS035/ SD036/SD037 plume.
SD043	Migration Control	GET	Conventional extraction well, perfomance monitoring wells, UV/Ox/LGAC groundwater treatment at CGWTP via WTTP	IRA construction complete.
SS014/SD033/ SD037[b]	MNA	Groundwater monitoring	Trigger, point-of-compliance, and guard wells	IRA construction complete. Addresses portion of commingled plume that is not hydraulically captured by Source Control and Migration Control extraction systems.

[a] IRA objective specified in Groundwater NEWIOU or WABOU IRODs.
[b] Commingled plume.
[c] Conventional extraction well is a vertical extraction well without vacuum enhancement.

TABLE 2-5
Summary of the DP039 Component of the West Interim Remedial Action
Groundwater Five-Year Review, Travis Air Force Base, California

Contaminant Plume	Objective [a]	Implemented IRA	Primary Components	Status and Comments
DP039 Source Area	Source Control	Source area GET and vapor extraction and treatment	Source area DPE well, performance monitoring wells, VGAC vapor treatment at WTTP, UV/Ox/LGAC groundwater treatment at CGWTP via WTTP	Hydraulically captured portion of plume. Installation of additional extraction wells will depend on outcome of ongoing phytoremediation treatability study. Extracted groundwater flow to CGWTP via WTTP combined with LF008, West, and Central IRAs.
DP039	MNA	Groundwater monitoring	Trigger, point-of-compliance, and guard wells	IRA construction complete. Addresses leading edge portion of plume that is not hydraulically captured by Source Control extraction system.
DP039	Migration Control	Pending – GET (potential)	Potentially pending additional extraction wells and performance monitoring wells	Potential further construction deferred, pending completion of MNA evaluation and phytoremediation treatability study.

[a] IRA objective specified in the *Groundwater IROD for the WABOU*.

TABLE 2-6
Summary of the LF008 Component of West Interim Remedial Action
Groundwater Five-Year Review, Travis Air Force Base, California

Contaminant Plume	Objective [a]	Implemented IRA	Primary Components	Status and Comments
LF008	Migration Control	GET	Conventional extraction wells, performance monitoring wells, UV/Ox/LGAC groundwater treatment at CGWTP via WTTP	IRA complete. Extracted groundwater flow to CGWTP combined with DP039, West, and Central IRAs.

[a] IRA objective specified in the *Groundwater IROD for the WABOU*.

TABLE 2-7
Summary of the South Interim Remedial Action
Groundwater Five-Year Review, Travis Air Force Base, California

Contaminant Plume	Objective [a]	Implemented IRA	Primary Components	Status and Comments
SS030-onbase Source Area	Source Control	GET	Interceptor trench, performance monitoring wells, air stripper groundwater treatment at SBBGWTP	IRA construction complete. Extracted groundwater flow to SBBGWTP combined with SS030-offbase, SS029, and FT005-onbase flows.
SS030-offbase	Offbase Remediation	GET	Conventional extraction wells, performance monitoring wells, air stripper groundwater treatment at SBBGWTP	IRA construction complete. Extracted groundwater flow to SBBGWTP combined with SS030-onbase, SS029, and FT005-onbase flows.
ST032	Source Control	Free-product removal	Passive skimmer	IRA construction complete. Jet-fuel removal in one monitoring well.
SS029	Migration Control	GET	Conventional extraction wells, performance monitoring wells, air stripper groundwater treatment at SBBGWTP	IRA construction complete. Extracted groundwater flow to SBBGWTP combined with SS030- and FT005-onbase flows.
Southern SS016/ST032[b]	Migration Control	GET	None	IRA construction complete. Commingled plume hydraulically captured by SS029 extraction system.
FT005-onbase	Migration Control	GET	Conventional extraction wells, performance monitoring wells, air stripper groundwater treatment at SBBGWTP	IRA construction complete. Extracted groundwater flow to SBBGWTP combined with SS030 and SS029 flows.
FT005-offbase	Offbase Remediation	GET	Pending – Conventional extraction wells, performance monitoring wells, air stripper groundwater treatment at SBBGWTP	Pending completion of offbase plume delineation and GET system construction in mid-2003.

[a] IRA objective specified in the *Groundwater IROD for the NEWIOU*.
[b] Commingled plume.

2.5.5 Petroleum-only Contaminated Sites

POCO sites include SS014, ST018, ST027, and ST028. POCO sites are typically associated with surface and subsurface releases such as fuel spills, piping leaks, faulty OWSs, or leaking underground storage tanks. The POCO program includes the removal of underground storage tanks and the remediation of POCO soil and groundwater using the RBCA methodology described in the *POCO Sites Work Plan* (IT Corporation, 1996). Releases of petroleum products are not typically recognized as CERCLA contamination. Therefore, the POCO sites are not addressed in either of the existing groundwater IRODs. However, the Air Force does address petroleum contamination under CERCLA if it is commingled with CERCLA contaminants.

2.5.5.1 SS014 IRA

The SS014 IRA comprises the groundwater IRA at POCO Site SS014 Site 1. Passive skimming is currently being conducted at Site 1 to remove jet fuel floating on the water table. The dissolved fraction of the fuel contamination is addressed under the MNA action in the southern portion of the West IRA. Routine groundwater monitoring is conducted under the GSAP.

2.5.5.2 ST018 Risk-based Corrective Action

Implementation of a RBCA at POCO Site ST018, if required to address groundwater contaminated with fuel constituents, is pending. The site is currently a demonstration site for a natural attenuation study being conducted by the Lawrence Livermore National Laboratory. Routine groundwater monitoring is conducted under the GSAP.

2.5.5.3 ST027 Risk-based Corrective Action

Implementation of a RBCA at POCO Site ST027, if required to address groundwater contaminated with fuel constituents, is pending. Current activities at the site are limited to routine groundwater monitoring under the GSAP.

2.5.5.4 ST028 Risk-based Corrective Action

Implementation of a RBCA at POCO Site ST028, if required to address groundwater contaminated with fuel constituents, is pending. Current activities at the site are limited to groundwater monitoring under the GSAP.

2.6 Long-term Operation of Interim Groundwater Remedies

In combination, routine treatment plant O&M, the basewide GSAP, and ongoing free-product removal efforts comprise LTO of the existing Travis AFB groundwater IRAs. Table 2-8 summarizes the LTO requirements for each of the consolidated IRAs.

2.6.1 Groundwater Extraction and Treatment Systems

Currently, LTO is conducted for the active GET systems at multiple sites within the North IRA, Central IRA, West IRA, and the South IRA (refer to Table 2-8).

During 2003, additional LTO will be conducted for new GET systems at the following locations:

- **North IRA –** LF00C GET system planned for construction in summer 2003
- **South IRA –** FT005-offbase GET system planned for construction in summer 2003

Routine O&M of groundwater treatment facilities is conducted in accordance with the O&M manuals developed for the NGWTP (GTI, 1999), CGWTP (Radian International, 2002; CH2M HILL, 2000a), and SBBGWTP (CH2M HILL, 2000b).

Monitoring of groundwater extraction system performance is conducted under the Travis AFB GSAP.

2.6.2 Monitored Natural Attenuation Assessments

Ongoing assessment of MNA is being conducted at multiple sites within the consolidated IRAs under the Travis AFB GSAP (refer to Table 2-8). The LTO requirement will continue until sufficient data are collected to assess the need for continued monitoring of MNA parameters.

MNA assessments at IRP Sites SS015, ST032, and SS035 have been discontinued for the following reasons:

- **LF007C –** The onbase portion of the plume will be hydraulically captured and prevented from migrating offbase by the GET system planned for completion in 2003.
- **SS015 –** A treatability study using vegetable oil that might enhance MNA is underway.
- **ST032 –** The dissolved petroleum-fuel plume will be hydraulically captured by the SS029 extraction system.
- **SS035 –** The plume will be hydraulically captured by the SD037 extraction system.
- **SS016 –** The southern portion of the SS016 plume (i.e., the portion of the plume not hydraulically captured by TARA and OSA GET systems) will be hydraulically captured by the SS029 GET system.

2.6.3 Free-product Removals

LTO for free-product removal actions is currently underway at the following sites:

- **SS014 –** Passive skimming
- **SD034 –** Active and passive skimming

These removal actions will continue until free-product recovery rates do not warrant further skimming operations. Passive skimming at Site ST032 (MW246 x 32) was discontinued in September 2002. The presence of free product will continue to be monitored by the GSAP.

2.7 References

CH2M HILL. 2001a. Final *Long-Term Operation Strategic Plan, Version 1*. Installation Restoration Program. Travis AFB, California. 10 December.

TABLE 2-8
Summary of Consolidated Groundwater Interim Remedial Actions LTO Requirements
Groundwater Five-Year Review, Travis Air Force Base, California

			LTO Requirement				
				GSAP			
Consolidated IRA	Component Sites	Treatment Plant	Extraction, Conveyance, and Treatment System O&M	Extraction System Performance Monitoring	MNA	Free-product Removal (passive skimming)	Comments
North IRA	FT004	NGWTP	Ö	Ö	Ö	-	
	SD031	NGWTP	Ö	Ö	Ö	-	
	LF006	NGWTP	-	Ö	Ö[a]	-	
	LF007B	-	-	-	Ö	-	
	LF007C	NGWTP – Pending	Ö	Ö	-[a]	-	Pending construction in summer 2003.
	LF007D	-	-	-	Ö	-	
South IRA	SS030	SBBGWTP	Ö	Ö	-	-	
	SS029	SBBGWTP	Ö	Ö	-	-	
	ST032	SBBGWTP via SS029	-	-	-[a]	Ö	Jet fuel.
	Southern SS016	SBBGWTP via SS029	-	-	-[a]	-	
	FT005-onbase	SBBGWTP	Ö	Ö	-	-	
	FT005-offbase	SBBGWTP – Pending	-	-	-	-	Pending construction in 2003.
Central IRA	Northern SS016	CGWTP	Ö	Ö	-	-	
West IRA	SS014	CGWTP via WTTP	-	-	Ö	Ö	Site 1 jet-fuel floating product.
	SD033	CGWTP via WTTP	Ö	Ö	Ö	-	
	SD034	CGWTP via WTTP	Ö	Ö	-	Ö	Stoddard solvent floating product.
	SS035	CGWTP via WTTP	Ö	Ö	-[a]	-	
	SD036	CGWTP via WTTP	Ö	Ö	-	-	
	SD037	CGWTP via WTTP	Ö	Ö	Ö	-	
	SS041	CGWTP via WTTP	Ö	Ö	-	-	
	SD043	CGWTP via WTTP	Ö	Ö	-	-	
	SS015	-	-	-	-	-	Treatability study in progress.
	DP039	CGWTP via WTTP	Ö	Ö	Ö	-	Phytoremediation treatability study in progress.
	LF008	CGWTP via WTTP	Ö	Ö	-	-	
ST018 RBCA	ST018	-	-	-	-	-	Treatability study in progress.
ST027 RBCA	ST027	-	-	-	-	-	Pending RBCA.
ST028 RBCA	ST028	-	-	-	-	-	Pending RBCA.

[a]MNA at SS035, Southern SS016, and ST032 discontinued and no longer applicable because plume is hydraulically captured.

Notes:

- Not applicable
RBCA in accordance with *POCO Sites Work Plan* (IT Corporation, 1996).

CH2M HILL. 2000a. Final *West Treatment and Transfer Plant Interim Remedial Action Operations and Maintenance Manual (Addendum to the Central Groundwater Treatment Plant O&M Manual).* Installation Restoration Program. Travis AFB, California. 28 June.

CH2M HILL. 2000b. Draft *South Base Boundary Groundwater Treatment Plant Operation and Maintenance Manual, Revision 2*. North / East / West Industrial Operable Unit, Travis AFB, California. 14 December.

CH2M HILL. 2000c. Technical Memorandum: *Re-evaluation of Soil and Groundwater. Contamination at Building 916 (SD043)*. Travis AFB, California. February.

CH2M HILL. 1998a. Final *West/Annexes/Basewide Operable Unit Feasibility Study (FS) Report.* Installation Restoration Program. Travis AFB, California. 1 April.

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Figure
2-1 Geologic Map of Travis AFB and Vicinity
11 x 17 color

Figure 2-1 continued

Figure
2-2 Schematic Geologic Cross Section
8.5 x 11 b&w

Figure
2-3 November 2001 Groundwater Elevation Contours
11 x 17 color

Figure 2-3 continued

Figure
2-4 May 2002 Groundwater Elevation Contours
11 x 17 color

Figure 2-4 continued

Figure
2-5 Administrative Milestones
8.5 x 11 B&W

Figure
2-6 Operable Units and Sites
11 x 17 color

Figure 2-6 continued

Figure
2-7 Contaminated Groundwater Sites
11 x 17 color

Figure 2-7 continued

Figure

2-8 Consolidated Groundwater Interim Remedial Actions

11 x 17 color

Figure 2-8 continued

SECTION 3.0

North IRA Area

Section 3.0 reviews the interim actions in the NOU. Sites and actions taking place in the NOU are as follows:

- FT004/SD031 GET (Section 3.1)
- FT004/SD031 MNA Assessment (Section 3.2)
- LF006 MNA (Section 3.3)
- LF007 MNA Assessment (Section 3.4)
- LF007C GET (Section 3.5)

3.1 FT004/SD031 Groundwater Extraction and Treatment System

3.1.1 Site Description

Site FT004 covers approximately 30 acres in the northeastern portion of the EIOU and is the former FTA No. 3. The site was used for fire training exercises from 1953 to 1962. During these exercises, waste fuel, oils, and solvents were dumped onto frames or onto the ground and burned (Roy F. Weston, Inc., 1995). Some soil staining and stressed vegetation were observed during historical field investigations. The site is currently an unused, open field. Figure 3.1-1 shows the location of the monitoring wells at this site, as well as at adjacent Site SD031.

Site SD031 covers approximately 5.5 acres and encompasses Facility 1205 in the northeastern part of the EIOU. Facility 1205 was constructed in 1957, and operations currently include the maintenance and repair of diesel-powered generators. Wastes generated at the facility include oils, antifreeze, and solvents. A washrack, located just south of the facility, is used to clean diesel engine parts and discharges to an OWS. This washrack appears to be the source area for groundwater contamination in the area. Historical aerial photographs taken from 1958 to 1963 indicate that Facility 1205 might have been used as an aircraft maintenance hangar during that time.

Table 3.1-1 presents the chemicals of concern (COC) at FT004 and SD031.

3.1.2 Site History and Status

Sites FT004 and SD031 were selected for GET in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). As part of the IRA at these sites, the NGWTP, located near SD031, was constructed. Construction was completed in early 2000. The objective of the GET action is Source Control, including hydraulic containment and mass removal. The Source Control target areas were initially defined as those areas where VOC contamination is present at concentrations greater than 1,000 μg/L. However, the Air Force later decided to design the

GET system to extract and treat groundwater contaminated with VOCs at concentrations greater than 100 µg/L.

TABLE 3.1-1
Chemicals of Concern at Sites FT004 and SD031
Groundwater Five-Year Review, Travis Air Force Base, California

	FT004	SD031
COCs at Individual Sites	Bromodichloromethane, 1,4-dichlorobenzene, bis(2-ethylhexyl)phthalate	Benzene, carbon tetrachloride
COCs at Both Sites	TCE, 1,1-DCE, cis-1,2-DCE, 1,2-DCA, chloroform, vinyl chloride, nickel	

Notes:

DCE = dichloroethene
DCA = dichloroethane

An interim action was not specifically identified in the IROD to remedy groundwater contamination that is not within the Source Control target area. However, the Air Force recognized the need to conduct monitoring and evaluate natural attenuation to address contamination that is not captured by the GET system. Currently, MNA is ongoing in the southern portions of the plumes at Sites FT004 and SD031. Section 3.2 of this report addresses the MNA action in the southern portions of Sites FT004 and SD031.

The following historical investigations and actions have taken place at FT004 and SD031:

FT004

- An IRP Phase I Records Search concluded that there was potential for contamination at FTA No. 3 and that this site should be investigated further (Engineering Science, Inc., 1983).
- An IRP Phase II Confirmation/Quantification Stage 1 investigation was performed during 1984 and 1985. As part of this investigation, two monitoring wells (MW-131 and MW-132) were installed, and soil and groundwater samples were collected (Roy F. Weston, Inc., 1986).
- An IRP Stage 2 investigation was performed during 1987 and 1988. Four monitoring wells (MW-201, MW-202, MW-203, and MW-301) were installed, and additional groundwater and soil samples were collected. The Stage 2 investigation also included a soil gas survey and a review of historical aerial photographs (Roy F. Weston, Inc., 1990).
- A Resource Conservation and Recovery Act (RCRA) Facility Assessment was performed in 1991 and 1992. At FTA No. 3, investigations included the installation of three additional monitoring wells (MW-265, MW-266, and MW-267) and the collection of soil and groundwater samples (Roy F. Weston, Inc., 1992).
- Three phases of RI were performed at FTA No. 3 during 1993 and 1994. Activities included soil, sediment, and groundwater sampling, and installation of two more monitoring wells (MW-1029 and MW-1030). The RI included a risk assessment and identification of COCs, and recommended that FTA No. 3 (now being referred to as FT004) be included in the FS (Roy F. Weston, Inc., 1995).

- Ten rounds of groundwater samples were collected at FT004 between 1984 and 1994 in association with the above investigations (Roy F. Weston, Inc., 1995).

SD031

- Facility 1205 was first investigated as part of the RCRA Facility Assessment in 1991 and 1992, after being identified as a potential area of concern based on a preliminary review and visual site inspection. Two shallow soil borings were completed, and soil samples indicated the presence of VOCs, total petroleum hydrocarbons as gasoline (TPH-G), and total petroleum hydrocarbons as diesel (TPH-D). The RCRA Facility Assessment concluded that this site should be investigated further (Roy F. Weston, Inc., 1992).

- Additional investigation was performed during three phases of RI in 1993 and 1994. During this time, 10 monitoring wells were constructed (MW-1725, MW-1726, MW-1727, MW-1729, MW-1730, MW-1731, MW-1740, MW-1741, MW-1742, and MW-1743). Soil samples and three rounds of groundwater samples were collected as part of the RI. The RI also included a risk assessment and identification of COCs, and recommended that SD031 be evaluated in the FS (Roy F. Weston, Inc., 1995).

FT004 and SD031

- Collection of groundwater samples at FT004 and SD031 began as part of the GSAP in 1996, and samples have been collected at least semiannually since that time.

- GET was selected for FT004 and SD031 as part of the NEWIOU FS and IROD at Travis AFB (Travis AFB, 1997).

- An Interim Remedial Design was completed in 1999. This design included a predesign investigation that further characterized groundwater at the sites, including aquifer testing and HydroPunch® sampling (CH2M HILL, 1999a).

- The NGWTP was constructed in 1999, and became operational 16 March 2000. Eight extraction wells (EW576x04 through EW580x04 and EW565x31 through EW567x31) and 20 monitoring wells (MW581x04 through MW592x04 and MW568x31 through MW575x31) were constructed to support the NGWTP (CH2M HILL, 2002a).

Through the end of September 2002, the NGWTP had treated 26.8 million gallons of groundwater, and the plant had removed approximately 357.6 pounds of VOCs, including 132.8 pounds from groundwater and 224.8 pounds from soil vapor (URS Group, 2002a)

3.1.3 Interim Remedial Action

The following IRA and objective was selected for FT004 and SD031 in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997):

- Action: Alternative 3—Extraction, Treatment, and Discharge
- Objective: Source Control (defined as TCE concentrations exceeding 100 µg/L)

MNA is the selected remedy for the portion of the plume downgradient from the 100-µg/L isopleth.

3.1.3.1 Remedy Description

The NGWTP uses an air stripper to remove VOCs from extracted groundwater and activated carbon vessels to remove VOCs from extracted soil vapors. The extraction system consists of five DPE wells at FT004 and three DPE wells at SD031 (each pumping at a target flow rate of 3 gallons per minute [gpm]). DPE was selected to provide vacuum enhancement of groundwater recovery. Figure 3.1-2 presents the process flow diagram for the NGWTP.

After extraction, pipelines convey contaminated groundwater and vapor to the NGWTP, located near Facility 1205, where the contaminated vapor and groundwater are treated (see Figure 2-6). Treated vapor meeting the emission requirements of the Bay Area Air Quality Management District's (BAAQMD) Regulation 8, Rule 47, is discharged to the atmosphere. Treated groundwater meeting the discharge limits specified in the *Amended Groundwater IROD for the NEWIOU* is pumped into a 42,000-gallon-capacity irrigation storage tank. Treated water is pumped from the tank to the duck pond, or can be stored in the tank to be used for other purposes such as dust suppression or irrigation. During May through September 2002, nearly 98 percent of the treated water was discharged to the duck pond (URS Group, 2002a).

3.1.3.2 Implementation

The NGWTP was constructed during 1999 and 2000, and came online 16 March 2000. When the plant first started operations, the treated groundwater was discharged from the NGWTP into the storm sewer system or used for irrigation purposes. During December 2001, effluent from the NGWTP began being discharged to the Duck Pond (Groundwater Technology, Inc., 2002).

A sequestering agent system was installed at the NGWTP on 30 July 2002, and became operational on 1 August 2002. The metering pump was set to deliver approximately 0.8 gallon of sequestering agent to the treatment stream per day. The purpose of the agent is to prevent the precipitation and deposition of minerals in the stripper. Periodic observations of the duck pond at the location of the treated water outfall have not revealed any significant algae growth or discoloration. The duck pond will continue to be monitored for potential impacts from the effluent (URS Group, 2002b).

3.1.3.3 Operations

The NGWTP is designed to achieve the objective stated in the IROD – namely, hydraulic capture of contaminated groundwater in the source areas at FT004 and SD031. The GET system is achieving this objective and is preventing migration of groundwater contamination beyond the source areas. The air stripper has proven effective in treating the extracted groundwater to below discharge limits.

Throughout the operation of the NGWTP, the project team has identified issues that have required modification of either the physical system or O&M procedures. Table 3.1-2 summarizes O&M issues and the corrective actions taken.

The plant is designed to operate unmanned, although monitoring and maintenance are required. O&M labor requirements vary from month to month. Plant sampling is typically performed monthly. Water and vapor samples are collected from the plant influent and effluent to track trends in influent concentration and demonstrate compliance with discharge standards. The rate of mass removal is expected to steadily decline.

Plant monitoring is performed in accordance with the *NGWTP O&M Manual, Site FT004 and SD031*. Monitoring typically consists of inspecting the plant and recording key system parameters (i.e., flow rate and pressures). The sampling and monitoring frequency is outlined in the *NGWTM O&M Manual, Site FT004 and SD031* (Groundwater Technology Inc., 1999).

TABLE 3.1-2
NGWTP O&M Issues and Corrective Actions Taken
Groundwater Five-Year Review, Travis Air Force Base, California

Date or Period of Time	System Issue	Corrective Action Taken
Ongoing	The wet well is translucent high-density polyethylene, which promotes algal growth. Because it is high-density polyethylene, it cannot be painted to exclude light (Groundwater Technology, Inc., 2001b).	Frequent cleaning of the wet well prevents fouling of water filters.
Seasonal	During the wet season, high groundwater elevations often rise above the top of the SVE screens (Groundwater Technology Inc., 2001b).	Shut down SVE system during the wet season.
June 2000	Treated groundwater effluent exceeded discharge limits as established in the IROD, and a Notice of Violation was issued by RWQCB. The exceedance was caused by a piping connection between the SVE system and air stripper vapor exhaust. High vapor pressure from the SVE system caused the air stripper to inadequately strip contaminants from the water (Groundwater Technology Inc., 2001a).	Removed section of pipe between the SVE system and the air stripper exhaust.
July 2000	Samples from the effluent holding tank collected following the discharge exceedance (see above) indicated that the treated water contained 2-butanone methyl ethyl ketone. The source of methyl ethyl ketone is believed to be microbial or temperature degradation of naturally occurring hydrocarbons in the groundwater and stagnation in the irrigation tank (Groundwater Technology Inc., 2001a).	Reconfigured the float switches in the tank to minimize water storage.
Second and Third Quarters 2001	High-density polyethylene-to-steel joints in down-well piping suffered severe galvanic corrosion when threaded into brass eductor pumps, causing leaking at the joints in wells EW565x31, EW567x31, and EW580x04 (Groundwater Technology Inc., 2001b).	High-density polyethylene-to-steel joints replaced with Schedule 80 polyvinyl chloride piping to eliminate steel transition fittings.
Startup until August 2002	The downstream side of the air stripper pump often had excessive buildup of carbonate scale, necessitating pump maintenance or replacement (URS Group, 2002b).	Cleaned the system periodically until a sequestering agent was injected to prevent the scaling.

Notes:

SVE = soil vapor extraction

3.1.4 Groundwater and Soil Vapor Treatment

This section presents a summary of treatment system parameters and components and a discussion of system performance metrics, discharge standards, and O&M cost and trends.

3.1.4.1 Treatment System Parameters and Components

Table 3.1-3 presents a summary of design and actual treatment system parameters for the NGWTP. Contaminant concentrations in groundwater have decreased dramatically with operation of the system, from a preremediation value of 1,422 µg/L to a current value of 210 µg/L. Air stripping remains an appropriate technology for removal of VOCs from groundwater at this site and consistently provides treatment to below discharge standards.

TABLE 3.1-3
NGWTP Design and Actual System Parameters
Groundwater Five-Year Review, Travis Air Force Base, California

Parameter	Design	Actual[a]
Air Stripper		
Groundwater Flow Rate (gpm)	27	15.6
Air Flow Rate (scfm)	600	750
Influent Groundwater Contaminant Concentrations (µg/L)		
TCE	1,422	100
1,1-DCE	392	21
1,1,1-TCA	171	27
1,1-DCA	33	0.55J
cis-1,2-DCE	16	1.8
1,2-DCA	2	ND
SVE Rate (scfm)	270	0[b]
Influent Soil Vapor Contaminant Concentrations (parts per million by volume)		
TCE	1.0	NA [c]
1,1-DCE	0.28	NA [c]
1,1,1-TCA	0.12	NA [c]
1,1-DCA	0.02	NA [c]
cis-1,2-DCE	0.01	NA [c]
1,2-DCA	0.0014	NA [c]

[a]As of December 2002.

[b]System was shut down December 13, pending VOC speciation results and treatment evaluation.

[c]Current speciated VOC data are not yet available. In September 2002, total VOC concentration was measured with a photoionization detector meter to be 342 parts per million by volume. Later analyses indicated that petroleum hydrocarbons comprise the majority of contaminant mass in the vapor stream.

Notes:

scfm = standard cubic feet per minute
TCA = trichloroethane
NA = not available
ND = nondetect
J = estimated or analyte concentration is considered an estimated value

Contaminant concentrations in soil vapor are now known to be higher than were anticipated during the design stage. Vapor contaminant concentrations as high as 342 parts per million by volume total VOCs were measured in September 2002 at EW566x04 using a photoionization detector. The speciation of contaminants in soil vapor at the site is currently under evaluation. The vapor treatment train might require modification to provide sufficient capacity for the increased mass loading. In the interim, vapor extraction from the DPE wells will be shut off, and groundwater extraction will continue.

3.1.4.2 Performance Goals and Metrics

The performance metrics presented and discussed in this section are based on RPO strategies presented in Section 5.0 of the *LTO Strategic Plan* (CH2M HILL, 2001a) and in the RPO Handbook (U.S. Air Force, 1999).

The analyses presented in this section are also presented quarterly in the O&M reports and are designed to address the NGWTP effectiveness in meeting Travis AFB's four main objectives for onbase groundwater treatment facilities:

1. Collect data to assess attainment of cleanup goals
2. Reduce operating costs
3. Reduce time to cleanup
4. Maintain compliance with IROD discharge limits

The first and third objectives, to meet IROD cleanup goals and reduce time to cleanup, are discussed in this section. Reduction in operating costs is addressed in the cost evaluation presented in Section 3.1.4.5, and compliance with IROD discharge limits is addressed in Section 3.1.4.3.

At this time, the performance metrics presented in this section reveal few meaningful trends. This is due to the fact that the NGWTP has not yet been operated in a consistently steady manner for any length of time. Since its startup in December 2000, the NGWTP has experienced variations in flow rate and mass loading due to various operational issues and discontinuous well operation. These conditions have also created variations in treatment plant operating costs. It is anticipated that the completion of the offbase extraction system at LF007 and the resolution of SVE issues in 2003 will be the last major modifications to the system, after which time, the NGWTP will begin steady-state LTO; and significant trends in performance metrics should begin to emerge.

Collect Data to Assess Attainment of Cleanup Goals. The IROD cleanup goal for the main COC (TCE) in the NGWTP system is 5.0 μg/L. Progress toward achieving this goal in groundwater can be evaluated through examination of trends in influent VOC concentration and mass removal rate over time.

- **Influent VOC Concentrations –** Influent VOC concentrations at the NGWTP are monitored monthly. Figure 3.1-3 presents the measured influent VOC concentrations over time from January 2001 to December 2002. As shown on Figure 3.1-3, the total influent VOC concentration has fluctuated over time, with a strong overall decreasing trend. The influent VOC concentration has decreased by approximately 72 percent during this period. The steady decline in influent VOC concentration indicates that the extraction system has been effective in reducing contaminant concentrations in groundwater.
- M**ass Removal Rate –** As shown on Figure 3.1-4, the cumulative VOC mass removed by the NGWTP in groundwater between startup and December 2002 is approximately 135 pounds. A large amount of mass (likely several hundred pounds) was removed in the vapor phase when SVE was initiated at EW566x31 in September 2002. However, the mass removed may not be quantified because the vapor flow measurement was found to be erroneous. The rate of VOC mass removal in groundwater over time is presented on

Figure 3.1-5. As shown, the total mass removal rate has fluctuated between 0.0 and 0.36 pound of VOCs per day since plant startup. In general, the mass removal rate in groundwater is decreasing with time. As previously mentioned, the mass removal rate in the vapor phase is not reported due to unreliable vapor flow measurements.

Reduce Time to Cleanup. Reduction in time to cleanup may be achieved through regular review and optimization of system operating parameters. To achieve reduction in the time to cleanup, extraction rates must be periodically adjusted to provide the greatest mass removal rate possible while maintaining hydraulic capture of plumes. Plant uptime must also be maximized. NGWTP progress, in terms of flow rate and plant uptime optimization, are presented in this section.

- **Optimize Treatment Plant Flow Rate –** The average treatment plant groundwater flow rates and target flow rates from January 2001 to December 2002 are presented on Figure 3.1-6. As shown, the total target flow rate for the NGWTP is 27 gpm. The actual flow rate has fluctuated significantly as a result of operational issues, and has declined over the last 6 months to around 20 gpm. Vapor extraction has only been operational for two time periods: from June 2001 to December 2001, and from June 2002 to September 2002. Vapor flow rates were not recorded during 2001, and during the period of operation in 2002, the vapor flow meter was found to be malfunctioning. Therefore, no reliable record of vapor flow rate currently exists. The vapor flow meter will be repaired in January 2003, and recording of vapor flow rates will resume.
- **Maximize Treatment Plant Uptime –** The percent uptime goal for all treatment plants at Travis AFB is 100 percent. Although there are bound to be some unexpected shutdowns, with proper planning and maintenance, these occurrences can be minimized. The system uptime is determined by taking into account all factors that cause the plant to shut down. The NGWTP percent uptime is presented on Figure 3.1-7. In general, the percent uptime has remained close to 88 percent.

3.1.4.3 Groundwater Discharge Standards

All groundwater treatment plants at Travis AFB are required to comply with the substantive requirements of a National Pollutant Discharge Elimination System permit issued by the San Francisco Bay RWQCB. Specific requirements are described in RWQCB Order Number 99-051, which was issued to regulate the "Discharge or Reuse of Extracted and Treated Groundwater Resulting from the Cleanup of Groundwater Polluted by Volatile Organic Compounds."

Order Number 99-051 supercedes Order Number 94-081, which was referenced in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). Under the current order, the instantaneous maximum concentration limits have changed for some compounds, the 30-day median limits have been removed, and the inorganic limits were changed from concentration- to mass-based standards. The impact of these changes on treatment plant compliance with discharge requirements at Travis AFB has been minimal because no modifications to the standards for primary COCs at Travis were included. Each of the three plants must comply with both the standards for water reclamation and the standards for surface water discharge, since some fraction of the effluent from each plant is reused.

A complete description of requirements is provided in the RWQCB Order Number 99-051. All groundwater treatment plants at Travis AFB have been designed to achieve the discharge standards outlined in Order Number 99-051, and have demonstrated successful compliance.

Samples collected from the effluent stream in June 2000 indicated that the TCE concentration was above effluent discharge limits. Subsequently, an investigation was performed, and the cause of the problem was identified as low airflow through the air stripper, resulting in insufficient treatment of the extracted groundwater stream. The low airflow through the stripper was caused by backpressure from the SVE blower. The NGWTP system was modified to prevent mixing of air streams from the SVE blower and the air stripper blower, thereby preventing future backpressure conditions.

Treated water from the NGWTP is used primarily to fill the Duck Pond north of the NGWTP or for irrigating the nearby fields, and is occasionally discharged to the Base stormdrain. During normal operation, system monitoring is performed weekly, and system sampling is performed monthly to ensure that the NGWTP is operating in compliance with groundwater discharge standards. Additional sampling and monitoring may also be conducted as needed. Data obtained through monitoring and sampling efforts are presented to the regulatory agencies monthly via the *NGWTP Monthly Data Sheet*.

3.1.4.4 Vapor Treatment Standards

Two sources of air emission exist at the NGWTP, air stripper offgas and extracted soil vapor. Vapor emissions from all SVE and air stripping operations at Travis AFB must comply with Regulation 8, Rule 47, of the BAAQMD.

Offgas from the air stripper at the NGWTP meets the criteria for an exemption from this rule for small operations; therefore, treatment of this stream is not required. However, treatment of extracted soil vapor is required given current contaminant concentrations. The rule requires that treatment provide at least 90 percent reduction of contaminants (by weight). Based on recent events, it appears that the existing vapor treatment system might not have the capacity to treat the extracted vapor stream. Investigation of this issue is ongoing and is discussed further in Section 3.1.6.

3.1.4.5 Cost Evaluation

O&M costs for the NGWTP are tracked monthly and regularly reviewed to evaluate system cost effectiveness. Operating costs for the NGWTP reported in this section include the following components:

- Engineering
- O&M
- Performance monitoring (sampling and analysis)
- Reporting
- O&M Manual preparation and periodic revision
- Project management and administration
- Utilities

Plant operating costs, operating costs per unit mass contaminants removed, and cumulative operating cost versus cumulative mass removed are presented and discussed in this section.

The NGWTP has not yet achieved steady-state operation. Groundwater extraction has continued since startup, although operation of the SVE system has been intermittent. Therefore, the evaluation of system costs presented in this section should be considered preliminary. Once steady-state operation is achieved, trends in O&M cost will be closely analyzed to aid in system optimization. Cumulative operating cost as a function of cumulative mass removed is another useful performance metric for groundwater treatment plants, although this metric could not be evaluated for the NGWTP because cumulative operating costs are not currently available.

- **Operating Costs –** A 12-month rolling cost is typically used to evaluate trends in operating costs for groundwater treatment plants due to the high variability of costs from month to month. Over time, operating costs are expected to decrease as the system is optimized. The 12-month rolling average O&M cost for the NGWTP cannot be calculated because data prior to May 2002 are not available. In place of the 12-month rolling cost, the monthly O&M cost since May 2002 is presented on Figure 3.1-8. The average monthly O&M cost during this period is approximately $15,700. If this monthly cost were extrapolated out to a 12-month period, the annual cost would be $188,400 per year. For comparison, annual O&M cost for the NGWTP was estimated to be $120,000 in the *Remedial Action Strategic Plan* (Radian International, 1998a). Several factors could be contributing to higher O&M cost than expected, such as increased labor requirements as a result of a mid-year contractor change, increased reporting requirements, and unexpected system upsets.
- **Cost per Unit Mass Removed –** The cost per unit mass removed serves as another useful metric in evaluating the cost effectiveness of the remedy. The expected trend for this metric is an initial decrease (i.e., increase in plant efficiency), followed by an increase as operating costs remain at approximately the same level but the rate of mass removal begins to decrease. The cost per pound of VOCs removed at the NGWTP is presented as a function of time on Figure 3.1-9. As stated above, due to the lack of cost data prior to May 2002, the cost per pound data presented on Figure 3.1-9 represent a snapshot in time, and are less representative of actual costs than a 12-month rolling average cost per pound would be. However, in the absence of historical cost data, the data presented on Figure 3.1-9 provide some indication of approximate costs per pound. It should also be noted that the cost per pound of contaminants removed presented on Figure 3.1-9 is based on operation of the groundwater extraction system only because vapor flow rate measurements collected during the SVE operation period from June to September 2002 were determined to be unreliable. When SVE resumes, the cost per pound of contaminants removed will likely decrease because the mass removal rate will increase, and O&M costs remain approximately the same.

3.1.5 Groundwater Monitoring

Sites FT004 and SD031 are located on Younger Alluvium, which consists primarily of silts and clays that are relatively low in permeability and strongly anisotropic. The Younger Alluvium overlies a submerged bedrock valley composed of Nortonville Shale. This valley is bounded on the west by a ridge of Domengine Sandstone, which forms the hill on which the old Base hospital is located. All of these bedrock formations plunge to the southeast.

The following sections summarize the results of GSAP monitoring at FT004 and SD031 and discuss the results of groundwater modeling performed in support of the five-year review. A comprehensive treatment of GSAP data collected at these sites is found in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2002a).

3.1.5.1 Hydraulic Data and Modeling Results

Groundwater beneath the sites varies from approximately 8 to 20 feet below ground surface (bgs). On a seasonal basis, the water table has historically varied about 2 to 4 feet each year, with no long-term trends of rising or falling elevations. However, during 2000 and 2001, the groundwater elevation dropped from 5 to 10 feet in many wells. This was the result of groundwater pumping from the extraction wells.

Site-specific contours of groundwater elevation at FT004/SD031, as measured during the May 2002 (annual) event, are shown on Figure 3.1-10. This figure also shows predicted capture, based on modeling performed during the remedial design, and estimated capture based on updated modeling performed as part of the five-year review.

There are 11 shallow/deep monitoring well pairs at this site. Groundwater elevation measurements in these wells indicate that significant vertical gradients are observed at only two well pairs. In addition, the vertical gradients are in the opposite directions in these well pairs. These findings suggest that no significant shallow or deep permeable pathways exist at Sites FT004 or SD031 for the movement of contamination.

The hydraulic data and results of groundwater modeling at these sites led to the conclusions summarized in Table 3.1-4.

TABLE 3.1-4
Groundwater Conclusions from Hydraulic Data and Modeling
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	Regional flow in the vicinity of FT004/SD031 is southeasterly.
2.	The groundwater flow direction and gradient vary across FT004 and SD031, and primarily affected by various site extraction wells at these sites. Hydraulic gradients vary from about 0.003 foot/foot to about 0.05 foot/foot.
3.	An inward hydraulic gradient is well established at FT004, and centered on extraction well EW579x04.
4.	An inward hydraulic gradient likely exists at SD031, although the extent of capture at the southern end of the plume, near EW567x31, is less clear due to limited data points. Additional monitoring wells are needed in this area to confirm that groundwater contamination is being captured.
5.	Based on groundwater elevation contours and results of modeling, groundwater contamination above 100 µg/L is being captured at FT004 and SD031. The GET system is achieving its design objective.
6.	Vertical gradients vary across FT004 and SD031. Of the 11 well pairs at the site, only two pairs show any significant vertical gradient: well pair MW203x04 and MW301x04 (downward) and well pair MW590x04 and MW589x04 (upward). These vertical gradients are a result of ongoing pumping.

3.1.5.2 Groundwater Quality Data

Figure 3.1-11 shows TCE concentrations over time at FT004 and SD031, and Figure 3.1-12 shows 1,1-DCE concentrations at these sites. Figures 3.1-13 and 3.1-14 present time series plots of TCE and 1,1-DCE concentrations over time in selected FT004/SD031 extraction wells.

The main objective of groundwater monitoring at GET sites at Travis AFB is to verify that the Source Control objective is being achieved. Groundwater quality data collected from the monitoring network at FT004/SD031 support the conclusions summarized in Table 3.1-5.

TABLE 3.1-5
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	Samples from monitoring well pairs constructed near and downgradient of plume areas where the design objective is Migration Control show a trend of variable or declining VOC concentrations. There are no instances where VOC concentrations have increased in downgradient wells.
2.	Only TCE and 1,1-DCE are detected above IRGs in extraction wells at FT004 and SD031. Concentrations of these and other COCs are either stable or declining over time in these wells (see Figures 3.1-13 and 3.1-14).
3.	TCE concentrations are also declining in monitoring wells within the source zones at FT004.
4.	1,1-DCE concentrations continue to significantly decline within the source zone at SD031.
5.	No trends are observed in the samples collected from shallow or deep monitoring wells at FT004 or SD031 that indicate that contaminants are distributed or migrating preferentially in shallow or deeper zones.
6.	Nickel continues to be detected at concentrations above the IRG at well MW267x04, which is east of the VOC plume at FT004. The source of the nickel is not known, and the stainless-steel well screen does not appear to be the source. Nickel is not detected at elevated concentrations in nearby wells, and appears to be confined to the immediate vicinity of MW267x04. Nickel is detected below the IRG in both the influent and effluent at the NGWTP.

3.1.5.3 Time to Cleanup

Simulations of contaminant migration and estimates of the time to clean contaminated groundwater are only approximate. These simulations reflect available information describing the distribution of groundwater contaminants (and sources) and rates and directions of groundwater flow through the aquifer (present and future), in addition to the inherent limitations of technologies available to simulate contaminant transport in aquifers. Consequently, estimates of cleanup time are mainly of qualitative or comparative value and should not be taken as exact times to clean contaminated groundwater. Despite these limitations, cleanup times for TCE-contaminated groundwater in the area of FT004/SD031 have been estimated to facilitate the evaluation of existing FT004/SD031 GET systems.

The migration of TCE-contaminated groundwater in the areas of FT004/SD031 GET systems has been approximated using a series of mixing cell calculations simulating the flushing of uncontaminated groundwater through contaminated portions of the aquifer and extraction of contaminated groundwater by the extraction wells. Series of mixing cells were aligned with flowtubes converging to the extraction wells for the purposes of the calculations. The configuration of flowtubes and rates of groundwater flow through flowtubes were based on the results of a steady simulation of groundwater flow performed using the updated Basewide Groundwater Flow Model (Appendix A). The initial (present-day) distribution of

TCE at FT004/SD031 was estimated using groundwater quality data collected during the May 2002 GSAP monitoring event (Figure 3.1-11).

Simulations of TCE migration based on mixing cell (flushing) calculations are shown on Figure 3.1-15. The calculations suggest that TCE concentrations at SD031 are likely to drop to 5 µg/L over the next 10 to 15 years. TCE concentrations in the area of the FT004 GET system are likely to drop to 5 µg/L over the next 100 years under current operating conditions. As shown, the model predicts that contaminant migration will be successfully controlled over the next 100 years.

By way of contrast, estimates of time to cleanup derived during the FS at these sites concluded that TCE concentrations would drop to 5 µg/L in 28 years at SD031, and 95 years at FT004 (Radian Corporation, 1996). Therefore, current estimates have shortened the time to cleanup at SD031, and are approximately the same at FT004.

The results presented are based on the existing configuration of extraction wells at FT004/SD031, designed to control the migration of contaminated groundwater, rather than accelerate cleanup. System optimization, including the installation of additional extraction wells in high-concentration areas, will reduce cleanup times. Site FT004, in particular, would benefit from installation of one or more extraction wells in the source areas.

The results presented represent best estimates of possible outcomes over long periods of time under current operating conditions, provided as a potential basis for identifying and prioritizing areas of future investigation. These results are based on recent refinements to the Basewide Groundwater Flow Model (Appendix A), subject to verification and evaluation using GSAP and other field data.

3.1.6 Opportunities for Optimization

Opportunities for optimization, either in terms of reduced time to cleanup or reduced O&M cost, for the NGWTP system are identified in this section. Reducing O&M costs is especially important because since costs have risen during 2002 and 2003. The following potential areas for optimization are evaluated:

- Extraction well flow adjustments to increase mass removal rate and decrease O&M cost while maintaining IROD objectives
- Modification of ex situ treatment systems to reduce O&M cost
- Implementation of in situ technologies to reduce time to cleanup

Each potential area for optimization is discussed briefly in the following sections. Table 3.1-6 summaries the opportunities for optimization discussed below.

TABLE 3.1-6
Recommendations for Optimization at FT004 and SD031
Groundwater Five-Year Review, Travis Air Force Base, California

Recommendations for Optimization
1. Use groundwater modeling to reduce pumping in existing extraction wells and potentially stop pumping altogether in existing extraction wells.
2. Use groundwater modeling to identify locations for one or more new extraction wells that are closer to source areas.
3. Install additional monitoring wells southeast of existing extraction well EW567x31 and, if necessary, to monitor the performance of new extraction wells.
4. Consider expanding capacity to treat soil vapor.
5. Consider in situ technologies to reduce source area contaminant mass.

3.1.6.1 Extraction Well Flow Adjustment

It might be possible to reduce the number of extraction wells in operation or modify the pumping rates and still achieve the Source Control objective. As noted above, contaminant concentrations have decreased dramatically since the extraction system has been in operation. Recent sampling results have shown that the TCE concentrations in only two of the eight extraction wells (EW576x04 and EW579x04) remains above the 100-µg/L level. Groundwater modeling should be used to assess the potential impact of changes in extraction rates and/or shutting down extraction wells altogether.

3.1.6.2 Installation of Additional Extraction Wells

The objective of the IRA at these sites is Source Control. The remedial design focused on hydraulic containment of groundwater contaminated with TCE at concentrations of 100 µg/L or higher. The GET system is successfully achieving this objective.

However, as discussed above, contaminant concentrations have declined at FT004 and SD031, and the extent of groundwater contaminated above 100 µg/L is much more restricted. Ongoing extraction of groundwater at lower and lower concentrations will gradually become more expensive on a cost per pound basis. In addition, it will require a long time to achieve IRGs across the entire site (see Section 3.1.5.3).

Installation of additional extraction wells near the FT004 and SD031 source areas will allow for more efficient Source Control as the zone of contamination shrinks inward, and will also decrease the overall time required to achieve IRGs. Groundwater modeling should be used to identify the optimal locations for these wells. However, a qualitative assessment indicates that one or more additional extraction wells near and downgradient from MW131x04 at FT004 would be helpful. If stakeholders agree that additional wells will speed up remediation, then a project will be programmed, a design modification completed, and the wells installed. The existing extraction network at SD031 may be adequate.

3.1.6.3 Installation of Additional Monitoring Wells

Additional monitoring wells might be needed if new extraction wells are installed.

In addition, an additional shallow/deep monitoring well pair is recommended at Site SD031, southeast of existing extraction well EW567x31. Currently, a lack of data points in this area makes it difficult to conclude with certainty that hydraulic containment is being achieved.

3.1.6.4 Modification of Ex Situ Treatment System

The groundwater treatment train is well optimized, and no modifications are needed at this time. Air stripping is a cost-effective technology for the flow rates and contaminant concentrations at the NGWTP. However, the vapor treatment train may require modification, as discussed below.

In September 2002, rapid breakthrough of the VGAC occurred when SVE was initiated from EW566x31. Characterization of this vapor stream is ongoing. Depending upon the results of this characterization, additional vapor treatment capacity may be required, possibly in the form of additional carbon vessels, or the use of an alternative technology, such as ThOx. It is likely that with sustained vapor extraction, concentrations will decrease significantly within a matter of months. Therefore, if increased treatment capacity is deemed necessary, a temporary, portable system should be used. Monthly sampling and analysis for VOCs in the influent and effluent vapor stream is also recommended to ensure system optimization and compliance with discharge requirements.

The installation of additional SVE wells should also be considered to maximize mass removal in this apparent vadose zone hot spot and prevent migration to groundwater at Site SD031. Delineation of the nature and extent of vadose zone contamination is ongoing. Upon completion of this investigation, the implementation of SVE should be evaluated in detail.

3.1.6.5 Implementation of In Situ Technologies for Mass Removal

In situ technologies have the potential to decrease the time to cleanup, if implemented in the FT004/SD031 area. One of the lowest-cost in situ alternatives is enhanced bioremediation. Enhanced bioremediation has the potential to significantly decrease contaminant mass in place at the site and, thus, reduce the time the cleanup. Enhanced bioremediation can comprise a number of strategies, but generally consists of the injection of an electron donor into the subsurface to stimulate biological reductive dechlorination. This technology is potentially effective for the majority of all organic contaminants found at FT004 and SD031.

More aggressive in situ technologies such as chemical oxidation and thermal heating could also be considered, although they are unlikely to be cost effective given the dispersed nature of the FT004/SD031 plume. Such technologies are most cost effective for high-concentration source areas. The FT004/SD031 plume covers a large area at a relatively low concentration.

3.1.7 Technical Assessment Summary

3.1.7.1 Is the Remedy Functioning as Intended by the IROD?

Yes. Source control of TCE at concentrations above 100 μg/L is being achieved at FT004 and SD031. There is no evidence that any of the COCs, including TCE or 1,1-DCE, are migrating past the design capture zone. Samples from monitoring wells constructed near and downgradient of the design capture area show a trend of variable or declining VOC concentrations. In no instance have VOC concentrations increased in downgradient wells. TCE and 1,1-DCE are the only COCs that are still detected above IRGs in site wells, and concentrations of these contaminants are declining in all areas of the plumes, including the source areas.

3.1.7.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are currently no exposure pathways to potential human or ecological receptors. As long as an IROD governs remedial actions at Travis AFB, IRGs remain valid as cleanup levels. The RAO at these sites (e.g., source control) is being exceeded. The sites are located well within the interior of the base, and institutional controls and downgradient extraction systems at FT005 prevent any potential exposure pathway from being completed. There have been no changes in standards identified as ARARs in the IROD, no changes in land use, and no changes in the physical conditions at FT004 or SD031.

3.1.7.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. No information has been collected that suggests the remedy is not protective. Risks have been adequately addressed at these sites, and the sites are not subject to natural disasters.

3.1.8 Statement of Protectiveness

The GET remedy at Sites FT004 and SD031 is expected to be, or is protective of, human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

3.1.9 References

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Figure
3.1-1 FT004/SD031 Site Map
11 x 17 color

Figure 3.1-1 continued

Figure
3.1-2 NGWTP Process Flow Diagram
11 x 17 color

Figure 3.1-2 continued

Figure
3.1-3 NGWTP Influent Concentration over Time
8.5 x 11 b&w

Figure
3.1-4 NGWTP Cumulative VOC Mass Removed in Groundwater over Time
8.5 x 11 B&W

Figure
3.1-5 NGWTP Mass Removal Rate in Groundwater over Time
8.5 x 11 B&W

Figure
3.1-6 NGWTP Groundwater Flow Rate over Time
8.5 x 11 B&W

Figure
3.1-7 NGWTP Percent Uptime over Time
8.5 x 11 B&W

Figure
3.1-8 NGWTP Monthly O&M Cost over Time
8.5 x 11 B&W

Figure
3.1-9 NGWTP Cost per Pound VOCs Removed over Time
8.5 x 11 B&W

Figure
3.1-10 Groundwater Elevations Measured at FT004/SD031 during May 2002
11 x 17 color

Figure 3.1-10 back

Figure
3.1-11 TCE Distribution at FT004/SD031
11 x 17 color

Figure 3.1-11 continued

Figure 3.1-12 1,1-DCE Distribution at FT004/SD031

11 x 17 color

Figure 3.1-12 continued

Figure
3.1-13 TCE Chemical Time Series Plots for FT004/SD031 GET
8.5 x 11 b&w

Figure
3.1-14 1,1-DCE Chemical Time Series Plots for FT004/SD031 GET
8.5 x 11 B&W

Figure
3.1-15 Time to Cleanup Simulation for TCE at FT004/SD031
11 x 17 color

Figure 3.1-15 back

3.2 FT004/SD031 Monitored Natural Attenuation Assessment

3.2.1 Site Description

Site FT004 covers approximately 30 acres in the northeastern portion of the EIOU and is the former FTA No. 3. The site was used for fire training exercises from 1953 to 1962. During these exercises, waste fuel, oils, and solvents were dumped onto frames or onto the ground and burned (Roy F. Weston, Inc., 1995). Some soil staining and stressed vegetation were observed during historical field investigations. The site is currently an unused, open field. Figure 3.2-1 shows the location of the monitoring wells at this site, as well as at adjacent Site SD031.

Site SD031 covers approximately 5.5 acres and encompasses Facility 1205 in the northeastern part of the EIOU. Facility 1205 was constructed in 1957, and operations currently include the maintenance and repair of diesel-powered generators. Wastes generated at the facility include oils, antifreeze, and solvents. A washrack, located just south of the facility, is used to clean diesel engine parts and discharges to an OWS. This washrack appears to be the source area for groundwater contamination in the area. Historical aerial photographs taken from 1958 to 1963 indicate that Facility 1205 might have been used as an aircraft maintenance hangar during that time.

Table 3.2-1 presents the COCs at FT004 and SD031.

TABLE 3.2-1
Chemicals of Concern at Sites FT004 and SD031
Groundwater Five-Year Review, Travis Air Force Base, California

	FTOO4	SD031
COCs at Individual Sites	Bromodichloromethane, 1,4-dichlorobenzene, bis(2-ethylhexyl)phthalate	Benzene, carbon tetrachloride
COCs at Both Sites	TCE, 1,1-DCE, cis-1,2-DCE, 1,2-DCA, chloroform, vinyl chloride, nickel	

3.2.2 Site History and Status

Sites FT004 and SD031 were selected for GET in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). As part of the IRA at these sites, the NGWTP, located near SD031, was constructed. Construction was completed in early 2000. The objective of the GET action is Source Control, including hydraulic containment and mass removal. The Source Control target areas were initially defined as those areas where VOC contamination is present at concentrations greater than 1,000 µg/L. However, the Air Force later decided to design the GET system to extract and treat groundwater contaminated with VOCs at concentrations greater than 100 µg/L.

An interim action was not specifically identified in the IROD to remedy groundwater contamination that is not within the Source Control target area (i.e., groundwater contaminated with VOCs at concentrations less than 100 µg/L). However, the Air Force recognized the need to conduct monitoring and evaluate natural attenuation to address contamination that is not captured by the GET system. Currently, MNA assessment is ongoing in the southern portions of the plumes at Sites FT004 and SD031. Section 3.1 of this report addresses the GET action in the northern portions of Sites FT004 and SD031. Section 3.1.2 provides a detailed site history for the sites as a whole. Investigations and actions that have taken place specifically at the MNA portion of the sites include the following:

- In 1998, a Natural Attenuation Assessment Plan was prepared that specifies how natural attenuation assessments will be performed at Travis AFB (CH2M HILLCH2M HILL, 1998b).
- A Source Control predesign investigation was performed at Sites FT004 and SD031 in 1998 and 1999. This investigation was performed in support of the remedial design for the GET action, and the objectives were to define the extent of contamination and derive aquifer hydraulic information (CH2M HILLCH2M HILL, 1999a).
- A preliminary natural attenuation assessment was performed in 1999 and 2000. The objectives were to further define the extent of contamination to the nondetect boundary, further characterize the hydrogeology, perform a preliminary assessment of natural attenuation, and install monitoring wells to support long-term monitoring. Six monitoring wells (MW752x04 through MW757x04) were installed (CH2M HILLCH2M HILL, 2001b).
- In 2001, the *FT004/SD031 Natural Attenuation Assessment Work Plan* was prepared. This work plan specified groundwater monitoring on an ongoing basis during the interim period as part of the MNA assessment at FT004 and SD031. Monitoring has been performed as part of the GSAP (CH2M HILLCH2M HILL, 2001b; CH2M HILLCH2M HILL, 2002a).

3.2.3 Remedial Action

3.2.3.1 Remedial Action Objective

Sites FT004 and SD031 were not included in the IROD as sites subject to MNA assessment. As mentioned above, the Air Force voluntarily performed a preliminary assessment of MNA in the downgradient portion of these sites. Monitoring wells were installed as part of this assessment to permit ongoing monitoring during the interim period. This monitoring is part of the natural attenuation assessment; MNA has not been selected at FT004 or SD031, but is ***being assessed*** during the interim period.

The main objective of MNA is Migration Control. The ongoing assessment is designed to measure the success of this objective and determine whether the downgradient portion of the plumes at FT004 and SD031 are continuing to migrate, or are stable. Monitoring is conducted as part of the GSAP, and a conclusion is drawn annually in the GSAP Annual Report. This five-year review will also draw conclusions regarding whether or not the plume is migrating. Ultimately, when sufficient data are available, a Natural Attenuation Summary Report will be prepared that will recommend whether MNA should be selected as the final remedy at these sites (CH2M HILLCH2M HILL, 2001b).

3.2.3.2 Remedy Description

The remedy for the MNA portion of Sites FT004 and SD031 consists of ongoing groundwater monitoring.

Currently, 20 monitoring wells are sampled to support the ongoing MNA assessment. These include the following:

- **Plume Wells –** MW133x03, MW206x03, MW134x04, and MW1002x04; and well pairs MW589x04 and MW590x04, MW591x04 and MW592x04, MW756x04 and MW757x04, MW572x31 and MW573x31, and MW574x31 and MW575x31
- **Crossgradient Well –** MW755x04
- **Downgradient Wells –** MW752x04 and well pairs MW205x03 and MW302x03 and MW753x04 and MW754x04

Originally, the *FT004/SD031 Natural Attenuation Assessment Work Plan* designated 17 monitoring wells as trigger wells, point-of-compliance wells, and guard wells. These wells were sampled quarterly for 2 years. After the 2-year period was over, sampling began being governed by the Decision Tree that guides all GSAP sampling. Based on the Decision Tree, the number of wells increased, and the frequency of sampling decreased (CH2M HILLCH2M HILL, 2002a).

3.2.4 Groundwater Monitoring

The following sections summarize the results of groundwater monitoring conducted as part of the GSAP to support evaluations of plume stability and the viability of MNA as a final remedy for the southern portion of Sites FT004 and SD031. A comprehensive description of hydrologic and contaminant data collected at the sites is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILLCH2M HILL, 2002a).

3.2.4.1 Hydraulic Data

The hydrogeology and general hydrologic conditions at FT004 and SD031 are described in Section 3.1.5.

Review of hydraulic data led to the conclusions presented in Table 3.2-2 concerning hydrologic conditions south of the FT004/SD031 GET systems.

TABLE 3.2-2
Conclusions Concerning Hydrologic Conditions South of FT004/SD031 GET Systems
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is 9 to 13 feet bgs.
2.	Groundwater flow is southeasterly.
3.	Groundwater from FT004 and SD031 appears to converge in the southern portion of the sites (area of MW752x04, MW753x04, and MW75x04) and continues to the south (Figure 3.1-10).
4.	Lateral hydraulic gradients vary from 0.02 foot/foot south of MW1001x04 to 0.002 foot/foot in the area of converging flow.
5.	No significant vertical hydraulic gradients (greater than ± 0.05 foot/foot) were observed during the 2001-2002 GSAP in the area south of FT004/SD031 GET systems.

3.2.4.2 Groundwater Quality Data

Figure 3.1-11 shows TCE concentrations detected in the May 2002 GSAP event, and Figure 3.1-12 shows 1,1-DCE concentrations at these sites. Figures 3.2-2 and 3.2-3 present time series plots of TCE and 1,1-DCE concentrations over time in selected FT004/SD031 MNA monitoring wells.

The main objective of groundwater monitoring at MNA sites at Travis AFB is to verify plume containment during the interim period. Containment is the ultimate test of natural attenuation. If MNA is not effective in controlling migration, the Air Force and regulators will evaluate alternative remedies. Groundwater quality data collected from the monitoring network at FT004/SD031 support the conclusions summarized in Table 3.2-3.

TABLE 3.2-3
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	The plume does not appear to be migrating at FT004 and SD031.
2.	No trends of increasing VOC concentrations have recently been observed in the FT004 and SD031 monitoring wells. In fact, TCE and 1,1-DCE concentrations appear to be declining in the FT004 and SD031 plume wells. This trend of decreasing COC concentrations at plume wells is illustrated for selected wells on Figures 3.2-2 and 3.2-3. The decline of COC concentrations observed in these wells is attributed to the operation of the GET system.
3.	In the 2001-2002 GSAP, TCE and 1,1-DCE were not detected above IRGs in FT004 and SD031 monitoring wells that were originally designated as point-of-compliance or guard wells in the *FT004/SD031 Natural Attenuation Assessment Work Plan*. Plume wells with TCE and/or 1,1-DCE concentrations detected above the IRGs are located within the modeled extent of hydraulic capture of the GET system.
4.	In the 2001-2002 GSAP, only one monitoring well located outside the modeled extent of hydraulic capture (MW1002x04) had a COC detected at a concentration above IRGs. 1,2-DCA was detected at a concentration of 1.3 µg/L at this well; the IRG is 0.5 µg/L.
5.	Freon 113, which is not a site COC, was detected at a few SD031 MNA monitoring wells during the 2001-2002 GSAP. The MCL for this chemical is relatively high (1,200 µg/L), and it was detected in one well (plume well MW206x03) at a concentration of 1,500 µg/L. The chemical is confined to Sites SD031 and FT003, and concentrations detected in other monitoring wells were well below the MCL. Ongoing monitoring will continue to track the Freon 113 at SD031.

3.2.5 Technical Assessment

3.2.5.1 Is the Remedy Functioning as Intended by the IROD?

Yes. As mentioned above, the IROD only specifies Source Control for FT004 and SD031. The Air Force has exceeded IROD requirements by implementing MNA assessment at these sites. To date, the monitoring results indicate that the MNA objective is being achieved; namely, there are no indications of plume migration. Contaminant concentrations in samples collected from both plume wells and downgradient wells have remained stable or declined over time.

3.2.5.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are currently no exposure pathways to potential human or ecological receptors. The sites are located well within the interior of the base, and institutional controls and downgradient extraction systems at FT005 prevent any potential exposure pathway from being completed. There have been no changes in standards identified as ARARs in the IROD, no changes in land use, and no changes in the physical conditions at FT004 or SD031.

3.2.5.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. The remedy is protective. Freon 113, which is not a site COC, has been detected above the MCL (1,200 µg/L) in one well. However, to date, the distribution of this chemical is limited to only four wells; concentrations have been very low (25 µg/L or less) in all but one well, and there is no evidence that the chemical is migrating.

3.2.6 Statement of Protectiveness

The MNA remedy at Sites FT004 and SD031 is expected to be, or is protective of, human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

3.2.7 References

CH2M HILLCH2M HILL. 2002a. Draft *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report*. Travis AFB, California. November.

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Figure
3.2-1 FT004/SD031 Site Map
11 x 17 color

Figure 3.2-1 back

Figure
3.2-2 TCE Chemical Time Series Plots for FT004/SD031 MNA
8.5 x 11 b&w

Figure
3.2-3 1,1-DCE Chemical Time Series Plots for FT004/SD031 MNA
8.5 x 11 b&w

3.3 LF006 Monitored Natural Attenuation

3.3.1 Site Description

Site LF006 (Landfill 1, or LF-1) is a former burn-and-fill landfill that was operated between 1943 and the early 1950s. The former landfill is in the northeastern corner of Travis AFB and is composed of approximately 17 acres. Materials disposed of and burned in the landfill consisted primarily of general refuse such as wood, paper, glass, and residential and construction debris, although some disposal of industrial wastes was reported (Radian Corporation, 1996a). A trailer park was built over the northern half of the site in 1970 but is no longer in use. Figure 3.3-1 shows the site features and locations of monitoring wells.

COCs at LF006 include the following: TCE, 1,1-DCE, TPH-D, and TPH-G.

3.3.2 Site History and Status

Site LF006 was selected for MNA in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). The site underwent a natural attenuation assessment in 1998, as specified in the *Natural Attenuation Assessment Plan* (CH2M HILLCH2M HILL, 1998b). The natural attenuation assessment was later documented in the LF006 *Natural Attenuation Assessment Work Plan* (CH2M HILLCH2M HILL, 1999b). The *Natural Attenuation Assessment Work Plan* concluded that MNA is a viable option at LF006, and recommended ongoing monitoring for COCs during the interim period to confirm plume stability and support a future evaluation of MNA as a final remedy for the site (CH2M HILLCH2M HILL, 1999b).

The following investigations and actions have taken place at LF006:

- An IRP Phase I Records Search concluded that there was potential for contamination at LF-1 and that this site should be investigated further (Engineering Science, Inc., 1983).
- An IRP Phase II Confirmation / Quantification Stage 1 investigation was performed during 1984 and 1985. As part of this investigation, one monitoring well (MW-130) was installed, and groundwater samples were collected (Roy F. Weston, Inc., 1986).
- An IRP Stage 2 investigation was performed during 1987 and 1988. Five monitoring wells (MW-207, MW-208, MW-209, MW-210, and MW-304) were installed, and groundwater and soil samples were collected. The Stage 2 investigation also included a soil gas survey and a review of historical aerial photographs (Roy F. Weston, Inc., 1990).
- A RCRA Facility Assessment was performed in 1991 and 1992. Investigations at LF-1 included the installation of two additional monitoring wells (MW-258 and MW-259) and the collection of soil and groundwater samples (Roy F. Weston, Inc., 1992).
- Round 1 and Round 2 of the RI were performed at LF006 in 1994. The investigations included the collection of soil gas, surface emission flux, surface water, sediment, surface soil, soil boring, in situ groundwater samples, and groundwater samples from existing monitoring wells. No new monitoring wells were installed at LF006 during the RI (Radian Corporation, 1995).

- Site LF006 was evaluated as part of the NEWIOU FS in 1996. Alternative 2—Natural Attenuation / Monitoring was selected for LF006 (Radian Corporation, 1996a).
- Groundwater samples began being collected at LF006 on a routine basis as part of the GSAP in 1996, and GSAP sampling continues to the present.
- A predesign investigation was performed at LF006 in 1998, to support a preliminary screening of LF006 for natural attenuation. The investigation included the drilling of soil borings and collection of in situ groundwater samples, and the installation of six monitoring wells (MW01Sx06, MW01Dx06, MW02Sx06, MW02Dx06, MW208Dx06, and MW258Dx06). The *Natural Attenuation Assessment Work Plan* that was prepared suggested MNA was a viable interim remedy at LF006 and identified 12 monitoring wells for ongoing quarterly monitoring (CH2M HILLCH2M HILL, 1999b).
- Two years of quarterly monitoring were completed in 2001. Since then, 11 monitoring wells have been sampled on an ongoing basis as part of the GSAP, based on the criteria presented in the Decision Tree (CH2M HILLCH2M HILL, 2001a).

3.3.3 Remedial Action

3.3.3.1 Remedial Action Objective

As mentioned above, Site LF006 was selected in the *Groundwater IROD for the NEWIOU* for Alternative 2—Natural Attenuation / Monitoring. LF006 was the only site selected for MNA in the IROD. Other sites were identified for MNA assessment during the interim period. LF006 was identified as a representative site for MNA because of existing evidence that natural attenuation was occurring (Travis AFB, 1997).

The main objective of MNA is Migration Control. The ongoing monitoring is designed to confirm whether the downgradient portion of the plume at LF006 is continuing to migrate, or is stable. Monitoring is conducted as part of the GSAP, and a conclusion is drawn annually in the GSAP Annual Report. This five-year review will also draw a conclusion regarding whether or not the plume is migrating. Ultimately, when sufficient data are available, a Natural Attenuation Summary Report will be prepared that will recommend whether MNA should be selected as the final remedy at LF006 (CH2M HILLCH2M HILL, 1999b).

3.3.3.2 Remedy Description

The remedy at LF006 consists of ongoing groundwater monitoring. Currently, 11 monitoring wells are sampled to support the ongoing MNA assessment and include the following (see Figure 3.3-1):

- **Upgradient Wells –** MW207x06 and MW210x06
- **Plume Wells –** MW208x06, MW208Dx06, MW259x06, MW1729x31, and MW1743x06
- **Downgradient Wells –** MW02Sx06, MW02Dx06, MW1730x31, and MW1731x31

3.3.4 Groundwater Monitoring

The following sections summarize the hydrogeology of Site LF006 and results of groundwater monitoring conducted as part of the GSAP to support evaluations of plume stability and the viability of MNA as a final remedy for the site. A comprehensive description of hydrologic and contaminant data collected at LF006 is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILLCH2M HILL, 2002a).

3.3.4.1 Site Hydrogeology

Site LF006 is located northwest of FT004/SD031 between Hospital Hill (an outcrop of Domengine Sandstone at the site of the old Base hospital) and a low hill approximately 1 mile east (outcrop of Markely Sandstone). The bedrock underlying LF006 consists of Nortonville Shale. This shale was eroded by ancient streams to form a south-trending valley in the bedrock surface. The bedrock valley was subsequently filled with alluvium as described in Section 2.1. Alluvium is 10 to 37 feet thick in the area of LF006 (based on drilling) and is composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay. Lenses and stringers of sand have been identified at depth in LF006 soil borings. Sand and silty sand were derived from nearby Domengine and Markley Sandstone.

3.3.4.2 Hydraulic Data

The water table is 9 to 15 feet bgs at LF006. On a seasonal basis, the elevation of the water table varies from 2 to 5 feet. However, no long-term trends in the elevation of the water table have been observed at the site.

Contours showing the elevation of the water table at LF006 during the May 2002 GSAP monitoring event are shown on Figure 3.3-2. Contours of measured groundwater elevations (Figure 3.3-2) indicate that groundwater flows south-southwest in the northern portion of LF006 and south-southeast in the southern portion of the site. Flow modeling performed as part of the five-year review (Appendix A) suggests that groundwater flows south to south-southeast through LF006. Vertical hydraulic gradients have been evaluated at the site using groundwater level measurements in shallow and deep well pairs.

Review of hydraulic data led to the conclusions presented in Table 3.3-1 concerning hydrologic conditions at LF006.

3.3.4.3 Groundwater Quality Data

Figure 3.3-3 shows TCE concentrations detected in the May 2002 GSAP event at LF006. Figure 3.3-4 presents time series plots of TCE concentrations over time in selected LF006 monitoring wells.

The main objective of groundwater monitoring at MNA sites at Travis AFB is to verify plume containment during the interim period. Containment is the ultimate test of natural attenuation. If MNA is not effective in controlling migration, the Air Force and regulators will evaluate alternative remedies. Groundwater quality data collected from the monitoring network at LF006 support the conclusions summarized in Table 3.3-2.

TABLE 3.3-1
Conclusions Concerning Hydrologic Conditions at LF006
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is 9 to 15 feet bgs.
2.	Groundwater flow is approximately south to south-southeasterly, but is affected on a seasonal basis by a groundwater mound that develops beneath vernal pools and former trenches to the east at adjacent Site LF007. In the winter, the direction of flow is often south-southwesterly.
3.	Lateral hydraulic gradients are approximately 0.004 foot/foot.
4.	If contaminated groundwater from Site LF006 migrates south, it will be captured by the SD031 extraction system.
5.	Vertical hydraulic gradients are generally small at LF006. Of the five shallow and deep well pairs at the site, only one showed significant vertical gradients (greater than ± 0.05 foot/foot) during the 2001-2002 GSAP, well pair MW258x06 and MW258Dx06 (upward). An upward gradient of 0.12 foot/foot was recorded at MW258x06/MW258Dx06 during February 2002 (the rainy season). Significant vertical gradients at this location are likely due to the tortuosity of the medium.

TABLE 3.3-2
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	The only COC consistently detected at LF006 has been TCE. However, the TCE concentrations have been stable or declining, and in most cases have been below the IRG (5.0 µg/L) for the last several years. Figure 3.3-4 illustrates the trend of decreasing TCE concentrations observed in many LF006 monitoring wells.
2.	The highest concentration of TCE detected at LF006 during the 2001-2002 GSAP was 8.2 µg/L (well MW1729x31 in the May 2002 event). TCE concentrations have decreased recently at this well. TCE was detected at a concentration of 15 µg/L during the March 2000 event, nearly twice the concentration that was detected in May 2002.
3.	The other site COCs (1,1-DCE, TPH-G, and TPH-D) were not detected in any of the LF006 wells during the 2001-2002 GSAP.
4.	Groundwater contamination at LF006 is contained, and the plume is not migrating. Natural attenuation appears to be a reasonable and effective interim remedy for this site.

3.3.5 Technical Assessment

3.3.5.1 Is the Remedy Functioning as Intended by the IROD?

Yes. Based on available data, the plume is not migrating and is slowly attenuating. COCs, such as 1,1-DCE, TPH-G, and TPH-D, are rarely or no longer detected in groundwater samples. TCE concentrations are low and are stable or declining. MNA has been successful at this site – the plume is stable and not migrating, and COCs are gradually dissipating. The site has been fully characterized, the plume is fully delineated, and MNA should eventually be designated as the permanent remedy at LF006.

3.3.5.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are currently no exposure pathways for human or ecological receptors. If groundwater contamination were to migrate, it would be captured by the downgradient SD031 extraction system. There are no changes in the anticipated land use at LF006 – the trailer park that was formerly located here has been closed and relocated. No new exposure pathways have been identified.

3.3.5.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. MNA is a protective remedy at LF006 and could be established as the permanent remedy at this site. Risks to potential human or ecological receptors have been adequately addressed, and LF006 is not subject to natural disasters.

3.3.6 Statement of Protectiveness

The MNA remedy at Site LF006 is expected to be or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

3.3.7 References

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Figure
3.3-1 LF006 Site Map
11 x 17 color

Figure 3.3-1 continued

Figure
3.3-2 Groundwater Elevations Measured at LF006 during May 2002
11 x 17 color

Figure 3.3-2 continued

Figure 3.3-3 TCE Distribution at LF006

11 x 17 color

Figure 3.3-3 continued

Figure
3.3-4 TCE Chemical Time Series Plots for LF006
8.5 x 11 b&w

3.4 LF007 Monitored Natural Attenuation Assessment

3.4.1 Site Description

Site LF007 is located at former Landfill 2 (LF-2) in the NOU and comprises approximately 73 acres in the northeast corner of Travis AFB along the Base boundary. The landfill was operated by trench-and-cover methods beginning in the early 1950s following the closure of LF-1 (Site LF006). The landfill was used primarily for the disposal of general refuse such as wood, glass, and construction debris. Small amounts of industrial wastes and fuel sludges from tank-cleaning operations were also reported to have been disposed at LF-2. Use of LF-2 ceased in 1974 (Radian Corporation, 1995). Figure 3.4-1 shows a site map of LF007, including the locations of monitoring wells.

From the early 1950s until 1964, a portion of the eastern part of the landfill was used by the Defense Property Disposal Office for the storage of excess and waste materials for resale or disposal, including oils, hydraulic fluid, and solvents. As determined by aerial photographs, a skeet range was also located at the site around 1953; however, the exact dates of operation are not known (Radian Corporation, 1995). Until 2002, extensive seasonal ponding occurred in the east-central portion of the site because of subsidence of the soil cover overlying the former landfill trenches. In 2002, regrading the area eliminated these areas of ponding and provided the subgrade for the Corrective Action Management Unit (CAMU). The CAMU will consolidate and cap contaminated soils excavated at the Base.

Currently located at LF007 are the operations at the Affiliate Radio System, the permitted hazardous waste storage facility, a small arms range, and the CAMU. Several large vernal pools are also located within the site boundaries. The land north of LF007, beyond the Base boundary, is privately owned and used for pasture. Large vernal pools extend across the Base boundary onto this property (CH2M HILLCH2M HILL, 2002a).

During the NOU RI, the LF007 site was divided into three study areas designated as Areas B, C, and D (i.e., LF007B, LF007C, and LF007D) (see Figure 3.4-1). Groundwater COCs were designated separately for each area. Table 3.4-1 lists the COCs within the LF007B, LF007C, and LF007C study areas.

TABLE 3.4-1
Chemicals of Concern at Site LF007
Groundwater Five-Year Review, Travis Air Force Base, California

Study Area	COCs
LF007B	Benzene, 1,4-dichlorobenzene, chlorobenzene, bis(2-ethylhexyl)phthalate, PCBs, and 2,3,7,8-tetrachlorodibenzo-p-dioxin
LF007C	TCE, vinyl chloride, 1,1-DCE, 1,2-DCA, 1,2-dichloropropane
LF007D	Benzene, vinyl chloride, 1,4-dichlorobenzene, 1,1-DCE, chlorobenzene, bis(2-ethylhexyl)phthalate, PCBs, and 2,3,7,8-tetrachlorodibenzo-p-dioxin

3.4.2 Site History and Status

The following historical investigations and actions have taken place at LF007:

- An IRP Phase I Records Search concluded that there was potential for contamination at LF-2 and that this site should be investigated further (Engineering Science, Inc., 1983).
- An IRP Phase II Confirmation / Quantification Stage 1 investigation was performed during 1984 and 1985. As part of this investigation, five monitoring wells (MW-125, MW-126, MW-127, MW-128, and MW-129) were installed, and groundwater samples were collected (Roy F. Weston, Inc., 1986).
- An IRP Stage 2 investigation was performed during 1987 and 1988. Two additional monitoring wells (MW-201 and MW-303) were installed, and groundwater and soil samples were collected. The Stage 2 investigation also included a soil gas survey, a geophysical investigation, and a review of historical aerial photographs (Roy F. Weston, Inc., 1990).
- A RCRA Facility Assessment was performed in 1991 and 1992. Investigations at LF-2 included the installation of three monitoring wells (MW-261, MW-264, and MW-284) and the collection of soil and groundwater samples (Roy F. Weston, Inc., 1992).
- Round 1 and Round 2 of the NOU RI were performed at LF007 in 1994. The investigations included the collection of soil gas, surface emission flux, surface water, sediment, surface soil, soil boring, in situ groundwater samples, and groundwater samples from existing monitoring wells. In addition, seven new monitoring wells (MW-A, MW-B, MW-C, MW-D, MW-E, MW-F, and MW-G) were installed and sampled at LF007 during the NOU RI (Radian Corporation, 1995).
- Site LF007 was evaluated as part of the NEWIOU FS in 1996. Alternative 2—Natural Attenuation / Monitoring and Alternative 3—Extraction, Treatment, and Discharge were selected for LF007 (Radian Corporation, 1996a).
- In 1996, routine groundwater sample collection began at LF007 as part of the GSAP and continues to the present day.
- A predesign investigation was performed at LF007 in 1998, to support a preliminary screening of LF007 for natural attenuation assessment. The investigation included the installation of three monitoring wells (MW600Sx07, MW601x07, and MW602x07) and the sampling of six wells. A *Natural Attenuation Assessment Work Plan for LF007* was prepared and concluded that MNA should continue to be assessed at LF007 during the interim period. Eighteen monitoring wells were identified for ongoing monitoring (Radian International, 1999).
- Groundwater sampling at LF007 began following the criteria presented in the Decision Tree in 2002 (CH2M HILLCH2M HILL, 2001a). Twenty monitoring wells were sampled at LF007 during 2002 as part of the GSAP (CH2M HILLCH2M HILL, 2002a).

The final decision regarding the Soil Remedial Action for LF007 will be made in the upcoming *NEWIOU Soil, Sediment, and Surface Water ROD*. In 2002, the design of the Soil Remedial Action for LF007 and post-construction activities to monitor and maintain the site were finalized (CH2M HILLCH2M HILL, 2002b). The LF007 Soil Remedial Action divides the site into four distinct zones: Zone 1 (CAMU), Zone 2 (area where contaminated surface soils will be excavated and placed in the CAMU), Zone 3A (fill placement area to re-establish adequate surface grades and drainage control), and Zone 3B (cleanup area for minor surface debris).

The CAMU may be constructed with an Applicable or Relevant and Appropriate Requirement-compliant ET final cover system using onsite stockpiled soil. If the onsite stockpiled soil is not acceptable for the final ET cover, other options may be considered. These may include importing soil, soil amendments, or use of a membrane final cover.

The ET system relies on the field capacity of the soil matrix and the ET capacity of a carefully selected plant community established on the final cover surface to store and remove moisture in the final cover and minimize percolation through the final cover. Construction of the subgrade for the CAMU began in June 2002. The elimination of the depressions caused by settling is anticipated to reduce seasonal surface water ponding at the landfill. Future groundwater elevation surveying will determine whether the groundwater mound beneath the site is reduced.

A groundwater interceptor trench has been constructed upgradient (relative to groundwater movement across the site) of the CAMU to physically capture and control groundwater elevations under the CAMU and maintain a minimum of 5 feet of separation between contaminated soil and groundwater. Collected groundwater will be conveyed around the CAMU and to an infiltration pit located downgradient of the CAMU (CH2M HILLCH2M HILL, 2002b).

Five additional monitoring wells were constructed in October 2002. Two of these, monitoring well pair MW612x07 and MW613x07, will be used to monitor for potential groundwater effects resulting from construction of the CAMU. The other three new wells (MW616x07, MW617x07, and MW618x07) were constructed near the Base boundary within LF007C to support monitoring of the new GET system. Two new extraction wells (EW614x07 and EW615x07) were also constructed, and two additional offbase monitoring wells are planned for construction offbase north of LF007C in the summer of 2003. Figure 3.4-1 shows these new wells.

3.4.3 Remedial Action

3.4.3.1 Remedial Action Objective

Areas B and D and the onbase portion of Area C at Site LF007 were selected in the *Groundwater IROD for the NEWIOU* for MNA assessment during the interim period. The offbase portion of Area C was selected for GET (see Section 3.5). As specified in the *Natural Attenuation Assessment Work Plan for LF007*, MNA assessment consists of ongoing groundwater monitoring (Radian International, 1999).

The main objective of MNA is Migration Control. The ongoing monitoring is designed to confirm whether the groundwater contamination at LF007 is migrating or is stable. Monitoring is conducted as part of the GSAP, and a conclusion is drawn annually in the GSAP Annual Report. This five-year review will also draw a conclusion regarding whether or not the plume is migrating. Ultimately, when sufficient data are available, a Natural Attenuation Summary Report will be prepared that will recommend whether MNA should be selected as the final remedy at LF007 (CH2M HILLCH2M HILL, 1998b).

3.4.3.2 MNA Remedy Description

The remedy at LF007 consists of ongoing groundwater monitoring. Currently, 20 monitoring wells are sampled to support the ongoing MNA assessment. Additional wells will be added in 2003 to support the GET assessment along the Base boundary. Table 3.4-2 shows wells selected for MNA assessment (see Figure 3.3-1).

TABLE 3.4-2
Monitoring Wells Selected for MNA Monitoring
Groundwater Five-Year Review, Travis Air Force Base, California

Study Area	Plume Wells	Downgradient Wells
LF007B	MW128x07 and MW303x07	MW207x07, MWGx07, and MW129x07
LF007C	MW125x07 and MW126x07	MW210x06 and MW602x07
LF007D	MWBx07, MWCx07, MW261x07, MW284x07, and MW601x07	MWAx07, MWDx07, MWFx07, MW201x07, MW264x04, and MW600x07

3.4.4 Groundwater Monitoring

The following sections summarize the hydrogeology of Site LF007 and results of groundwater monitoring conducted as part of the GSAP to support evaluations of plume stability and the viability of MNA as a final remedy for onbase groundwater contamination. A comprehensive description of hydrologic and contaminant data collected at LF007 is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL HILL, 2002a).

3.4.4.1 Site Hydrogeology

Site LF007 is located northeast of FT004 on the northeastern flank of an alluvium-filled bedrock valley. Nortonville Shale underlies LF007 and comprises the bedrock in the vicinity. This shale was eroded by ancient streams to form a south-trending valley in the bedrock surface. The bedrock valley was subsequently filled with alluvium as described in Section 2.1. Alluvium is up to 50 feet thick in the southwestern portion of LF007 (based on drilling). The thickness of alluvium decreases to the east. Alluvium is composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay at LF007. Sand and silty sand were derived from nearby Markley Sandstone.

In the area of former LF-2 (eastern portion of LF007), alluvium is overlain by municipal waste and backfill. The thickness of municipal waste ranges from a few feet to over 20 feet. Backfill is 1 to 5 feet thick. Wastes and fill settled in the eastern portion of the landfill, creating a south-trending depression. Regrading of the area and placing earthfill was completed in June 2002, in the first phase of CAMU construction (CH2M HILL, 2002b).

3.4.4.2 Hydraulic Data

The water table is generally 9 to 13 feet bgs at LF007. In the easternmost portion of the site (east of the landfill and Markley Sandstone outcrop), the water table is up to 27 feet bgs. A groundwater mound has formed in the area of the landfill due to the infiltration of ponded surface water. Historically, the greatest seasonal variations in the elevation of the water table have occurred in this area (up to 8 feet). Elsewhere, the elevation of the water table varies 2 to 6 feet annually. No long-term trends in the elevation of the water table have been observed at the site.

Figure 3.4-2 shows the water table elevation contours at LF007 during the May 2002 GSAP monitoring event. Groundwater flows radially away from the landfill (groundwater mound), including offbase to the north. Regrading of the area completed in June 2002 should lead to reduced seasonal surface water ponding, the size of the groundwater mound, and extent of radial groundwater flow. However, the presence of vernal pools in the area will ensure that some mounding will persist.

Groundwater flowing radially to the north converges with southeasterly flow (the regional flow field), and then flows south to southeast across the remainder of LF007 toward SD031 and FT004 (based on flow modeling performed as part of the five-year review). Vertical hydraulic gradients have been evaluated at the site using groundwater level measurements in a pair of shallow and deep wells (MW128x07 and MW303x07).

Hydraulic data have led to the conclusions presented in Table 3.4-3 concerning hydrologic conditions at LF007.

TABLE 3.4-3
Conclusions Concerning Hydrologic Conditions at LF007
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is generally 9 to 13 feet bgs. In the easternmost portion of LF007 (east of the landfill and Markley Sandstone outcrop), the water table is up to 27 feet bgs.
2.	A groundwater mound exists in the area of the former landfill due to the infiltration of ponded surface water. Regrading of the area (completed in June 2002) should lead to a reduction in seasonal surface water ponding and the size of the groundwater mound.
3.	Groundwater flows radially away from the landfill (groundwater mound), including offbase to the north. Regrading (completed in June 2002) should lead to a reduction in the size of the mound and extent of radial flow, although some mounding is expected to continue due to vernal pools.
4.	Pumping at offbase extraction wells (future GET system) will change directions and rates of groundwater flow at LF007.
5.	Lateral hydraulic gradients are at a maximum in the area of the landfill (groundwater mound), approximately 0.03 foot/foot, and about 0.003 foot/foot over the remainder of the site.
6.	Vertical hydraulic gradients are generally small at LF007. No significant vertical hydraulic gradients (greater than ± 0.05 foot/foot) were recorded at the MW128x07/MW303x07 well pair during the 2001-2002 GSAP.

3.4.4.3 Groundwater Quality Data

Figure 3.4-3 shows TCE concentrations detected in the May 2002 GSAP event. Figure 3.4-4 presents time series plots of TCE concentrations over time in selected LF007 monitoring wells.

The main objective of groundwater monitoring at MNA sites at Travis AFB is to verify plume containment during the interim period. Containment is the ultimate test of natural attenuation. If MNA is not effective in controlling migration, the Air Force and regulators will evaluate alternative remedies.

Groundwater quality data collected from the monitoring network at LF007 support the conclusions summarized in Table 3.4-4.

TABLE 3.4-4
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

Groundwater Quality Conclusions
1. With the exception of TCE concentrations in the vicinity of well MW125x07, groundwater contamination at LF007 appears to be stable. TCE concentrations are continuing to rise along the northern Base boundary at MW125x07, indicating that groundwater contaminated with TCE is migrating offbase in this area. A GET system is currently being constructed to address this portion of groundwater contamination at LF007.
2. Figure 3.4-4 illustrates that, with the exception of well MW125x07, monitoring wells with historical detections of TCE are now nondetect for the chemical.
3. Groundwater samples collected during the 2001-2002 GSAP from several wells in Areas C and D contained aromatic hydrocarbons, including benzene, 1,4-dichlorobenzene, and chlorobenzene. Affected wells included MW261x07, located in the center of the groundwater mound area, and other wells located potentially downgradient from MW261x07 (e.g., MWBx07 and MWCx07). However, concentrations of these chemicals are not increasing over time, and they were not detected in samples collected from monitoring wells farther downgradient along the Base boundary. Therefore, the contamination appears to be stable in this area.
4. No COCs were detected above IRGs in any well designated as downgradient at LF007 during the 2001-2002 GSAP monitoring period.

3.4.5 Technical Assessment

3.4.5.1 Is the Remedy Functioning as Intended by the IROD?

Yes. Except for offbase migration occurring along the northern Base boundary within LF007C, groundwater contamination remains stable. Concentrations of COCs in groundwater remain stable, declining, or are no longer detected. MNA is a successful remedy at LF007B and LF007D. Cleanup levels and plume containment should continue to be achieved at these subsites, and ongoing monitoring will assure protectiveness. Additional characterization and construction of a GET system are scheduled to address the groundwater contamination migrating offbase at LF007C in 2003 (see Section 3.5). This system will capture the groundwater contamination in this area, and will supercede the MNA assessment in LF007C. Therefore, the remedy is considered protective at LF007C on an interim basis.

3.4.5.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objects Still Valid?

Yes. There are currently no exposure pathways for human or ecological receptors in the MNA portion of the site. If groundwater contamination were to migrate, it would be captured either by the downgradient FT004 extraction system or by the new extraction system being installed along the Base boundary within LF007C. The land use has changed recently, with the construction of the CAMU over the old landfill. However, this change will only increase the protectiveness of the groundwater remedy by reducing infiltration and the hydraulic gradient. No new contaminants have been identified, and no new exposure pathways are present.

3.4.5.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. MNA is protective remedy at LF007 and could be established as the permanent remedy at this site. Risks to potential human or ecological receptors have been adequately addressed, and LF007 should not be subject to unanticipated natural disasters.

3.4.6 Statement of Protectiveness

The GET remedy at Site LF007 is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

3.4.7 References

CH2M HILL. 2002a. Draft *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report*. Travis AFB, California. November.

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Roy F. Weston, Inc. 1986. *Installation Restoration Program, Phase II Confirmation/Quantification Stage 1, Travis AFB, California.* April.

Figure
3.4-1 LF007 Site Map
11 x 17 color

Figure 3.4-1 continued

Figure
3.4-2 Groundwater Elevations Measured at LF007 during May 2002
11 x 17 color

Figure 3.4-2 continued

Figure
3.4-3 TCE Distribution at LF007
11 x 17 color

Figure 3.4-3 continued

Figure
3.4-4 TCE Chemical Time Series Plots for LF007
8.5 x 11 b&w

3.5 LF007C Groundwater Extraction and Treatment System

The GET IRA at LF007C will be constructed to achieve the following objectives:

- **Migration Control –** Prevent further offbase contaminant migration
- **Offbase Remediation –** Remediate the existing plume of offbase groundwater contamination

Construction of a Migration Control / Offbase Remediation GET system to achieve these objectives has begun, but is only partially complete. Figure 3.5-1 shows the locations of completed and planned extraction and monitoring wells. Through 2002, two onbase groundwater extraction wells and three performance monitoring wells have been installed, but the extraction system is not yet operational. Work to install the remaining extraction system components (e.g., pumps and control system), construct the groundwater conveyance system to the NGWTP, collect in situ groundwater samples to better delineate the offbase portion of the plume, and install two offbase performance monitoring wells will not be conducted until approximately mid-2003.

A large vernal pool overlies the area of LF007C groundwater contamination. Vernal pool fairy shrimp may exist in the pool during the wet season when surface water ponds in the area. This vernal pool in governed by the regulations and / or restrictions set forth by the U.S. Fish and Wildlife Service. The designed locations of most of the onbase and offbase groundwater monitoring wells lie within this vernal pool. Accordingly, the Air Force has formally consulted with the U.S. Fish and Wildlife Service and received Biological Opinion #1-1-02-F-0227. The biological opinion specifies the measures that must be taken during construction and operation of the IRA to ensure protection of the fairy shrimp and the vernal pool habitat. The following measures are required:

- Construction activities will occur during the summer months when the vernal pool is dry. Site conditions must allow access by drilling rigs and other heavy support equipment. Ground conditions must be sufficiently dry and firm to allow construction, or the schedule will be delayed.
- Extraction and monitoring wells within the vernal pool will be constructed to ensure no hydraulic connection exists between the surface water in the vernal pool and the underlying groundwater.
- Planking, or other protection of the ground, will be used to protect the ground surface within the vernal pool when a drilling rig and other support equipment is used.
- The perimeter of the vernal pool will be staked or roped off to control access into the vernal pool.

Additionally, the offbase portion of the LF007C plume underlies privately owned property. Travis AFB and the U.S. Army Corps of Engineers must first obtain an easement for access to the areas where offbase performance monitoring wells will be constructed before any field activities can be conducted.

The current extent of TCE contamination in the offbase portion of the LF007C groundwater contaminant plume is uncertain. Therefore, prior to the installation of the two offbase groundwater monitoring wells described in the remedial design (URS Group, 2002c), additional in situ groundwater samples will be collected and analyzed to define the current extent of contamination (CH2M HILL, 2002c).

The extent of LF007C-offbase groundwater contamination was last evaluated as part of the NOU RI in 1994. During this investigation, in situ groundwater samples were collected using cone penetrometer testing. However, no permanent groundwater monitoring wells were installed during the RI or any other subsequent event. Groundwater data obtained since the RI indicate that TCE concentrations are increasing along the northern Base boundary at onbase monitoring well MW125x07. This trend indicates that contaminated groundwater is migrating offbase in the area of LF007C. Additional data are required to assess the current extent of groundwater contamination and optimize placement of the LF007C offbase performance monitoring wells.

3.5.1 Statement of Protectiveness

The MNA remedy at Sites LF007B and LF007D is expected to be, or is protective of, human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled. The MNA remedy at Site LF007C is being replaced by a GET action (see Section 3.5).

3.5.2 References

CH2M HILL. 2002c. Predraft *LF007C-Offbase Interim Groundwater Remedial Action Work Plan.* 60 CES/CEVR. Travis AFB, California. 30 September.

URS Group. 2002c. Draft Final *LF007 Area C Interim Groundwater Remedial Design Report*. Installation Restoration Program. Travis AFB, California. 1 October.

Figure
3.5-1 LF007C Site Map
11 x 17 color

Figure 3.5-1 continued

SECTION 4.0

South IRA Area

Section 4.0 focuses on the interim action in the south Base area. The three sites in this area (FT005, SS029, and SS030) are all undergoing GET, with groundwater delivered to the SBB GWTP for treatment. Two of the sites (FT005 and SS030) have plumes that have migrated offbase. The third site (SS029) appears to be affected by contamination migrating from upgradient Site SS016.

4.1 FT005/SS029/SS030 Groundwater Extraction and Treatment System

4.1.1 Site Description

Site FT005 (formerly FTA-4) is located within the NEWIOU in the southeast portion of Travis AFB (see Figure 4.1-1). Contamination is the result of fire training exercises conducted between 1962 and approximately 1986. Historical photographs indicate that the area might have been used for munitions storage prior to 1958. From 1962 until the early 1970s, waste fuels, oils, and solvents were used as ignitable materials during fire training exercises. Soil contamination is generally limited to FTA-4. However, groundwater contamination has migrated offbase. Based on field investigations performed in 2002, a plume of 1,2-DCA contamination extends approximately 2,700 feet south of the Base boundary. Concentrations of 1,2-DCA are relatively low, but exceed the MCL of 0.5 μg/L. Section 4.2 provides more information regarding the offbase portion of FT005.

Site SS029 (MW329 Area) is also located in the southeast portion of Travis AFB, south of the runway, and west of FT005. The site location, an open field south of abandoned Taxiway R, is shown on Figure 4.1-1. The source of groundwater contamination at SS029 is unknown. Historical photographs indicate that airplanes had been parked in the vicinity of well MW329x29, but little else is known of historical activities at the site (Roy F. Weston, Inc., 1995).

Site SS030 (MW269 Area) is located south of Facility 1125 (a radar facility) and southwest of SS029, in the southeast portion of Travis AFB (see Figure 4.1-1). The SS030 site boundary encompasses an area of groundwater contamination that has migrated offbase for a distance of about 1,700 feet. Well MW269x30 was originally installed during the EIOU RI to evaluate groundwater quality along the southeast Base boundary. No known historical activities had indicated that groundwater contamination would be detected. However, the EIOU RI and subsequent investigations discovered that the groundwater was contaminated with TCE. Historical activities associated with Building 1125 in the vicinity of MW269x30 are believed to be the source of the solvent contamination at SS030 (CH2M HILL, 2002d).

Table 4.1-1 presents the COCs at Sites FT005, SS029, and SS030.

TABLE 4.1-1
Chemicals of Concern at Sites FT005, SS029, and SS030
Groundwater Five-Year Review, Travis Air Force Base, California

	FT005	SS029	SS030
COCs at Individual Sites	Bromodichloromethane, cis-1,2-DCE, bis(2-ethylhexyl)phthalate, nickel	Benzene, 1,1-DCE, cis-1,2-DCE, vinyl chloride	Bromodichloromethane, nickel
COCs at All Sites	TCE, 1,2-DCA, chloroform		

4.1.2 Site History and Status

Sites FT005, SS029, and SS030 were selected for GET in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). A groundwater IRA is currently in progress at Sites FT005, SS029, and SS030. The overall approach to cleanup at these sites is described in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). Migration Control is the primary objective of the IRA for the onbase portions of the plumes, and groundwater remediation is the primary objective for the offbase portions of the plumes at FT005 and SS030.

A pilot-scale groundwater treatment plant was constructed at Site SS030 during summer 1997, and became operational in July 1998. Previously referred to as the "SS030 Pilot Study Treatment Plant," the facility has now been designated by Travis AFB as the "South Base Boundary Groundwater Treatment Plant" (SBBGWTP). This designation more accurately describes the current capacity of the facility to treat contaminated groundwater from multiple sites in the southern area of Travis AFB (i.e., Sites FT005, SS029, and SS030) (CH2M HILL, 2002a).

The following historical investigations and actions have taken place at FT005, SS029, and SS030. Milestones, since the implementation of the IRA, are presented in Section 4.1.3.2.

FT005 (FTA–4)

- An IRP Phase I Records Search concluded that there was potential for contamination at FTA No. 4 and that this site should be investigated further (Engineering Science, Inc., 1983).
- An IRP Phase II Confirmation/Quantification Stage 1 investigation was performed during 1984 and 1985. As part of this investigation, four monitoring wells were installed (MW-117 through MW–120) to identify areas of concern for future field investigations (Roy F. Weston, Inc., 1986).
- An IRP Stage 2 investigation was performed during 1988. This more extensive field investigation was conducted to characterize the source area and define the extent of soil and groundwater contamination. Twelve soil borings were advanced, and two wells (MW-218 and MW-307) were installed. Other work included collection of soil, geotechnical, and soil gas samples, and the review of historical aerial photographs (Roy F. Weston, Inc., 1990).
- A RCRA Facility Assessment was performed in 1991. Two additional monitoring wells (MW-257 and MW-320) were installed, and surface and subsurface soil samples were collected (Roy F. Weston, Inc., 1992).

- Three rounds of RI were performed at FT005 during 1993 and 1994. Work included the installation of three monitoring wells (MW-1003, MW-1005, and MW-1006) and the collection of surface and subsurface soil samples, sediment samples, and groundwater samples (Roy F. Weston, Inc., 1995).

SS029 (MW-329 Area)

- MW-329 was installed in December 1993, during the EIOU RI as part of an effort to discover the source of the TCE previously observed at nearby well MW-269 (now Site SS030). After groundwater contamination was observed in this well, investigators realized that it represented a separate source area, and additional investigation was performed in this area to assess the origin and extent of contamination (Roy F. Weston, Inc., 1995).
- Seven additional monitoring wells (MW-1031, MW-1032, MW-1033, MW-1040, MW-1042, MW-1043, and MW-1044) were constructed during the third round of RI in the MW-329 area. Soil, in situ groundwater, and monitoring well groundwater samples were also collected (Roy F. Weston, Inc., 1995).

SS030 (Formerly MW-269 Area)

- MW-269 was originally constructed in 1991 during the RCRA Facility Assessment as part of an effort to develop a monitoring network along the south Base boundary. Investigators did not expect to discover that the groundwater was contaminated (Roy F. Weston, Inc., 1992).
- Three additional monitoring wells (MW-280, MW-281, and MW-282) were constructed in this area in 1992 to assess the extent of contamination (Roy F. Weston, Inc., 1995).
- As part of the RI in the EIOU, six more monitoring wells (MW-1009, MW-1010, MW-1017, MW-1034, MW-1035, and MW-1036) were constructed and sampled. In addition, the RI included the installation of piezometers; the collection of surface soil, subsurface soil, and in situ groundwater samples; and the performance of aquifer tests (Roy F. Weston, Inc., 1995).
- Groundwater extraction and treatment from MW-269 was initiated in May 1994 as a removal action. The system was operated as a pilot system until February 1995. Groundwater was extracted at a rate of 0.8 gpm and treated by granular-activated carbon (Roy F. Weston, Inc., 1995).

FT005, SS029, and SS030

- Sites FT005, SS029, and SS030 were evaluated as part of the NEWIOU FS in 1996. Alternative 3—Groundwater Extraction / Treatment was recommended for these sites (Radian Corporation, 1996a). This alternative was formally selected in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997).
- Routine collection of groundwater samples began as part of the GSAP in 1996, and GSAP sampling continues to the present.
- A 200-foot interceptor trench was constructed along the Base boundary south of MW-269 in summer 1997.

Historical details regarding the expansion and development of the SBBGWTP are provided in Section 4.1.3.3. The SBBGWTP currently treats and discharges to Union Creek and irrigation approximately 170 gpm of groundwater. Through the end of December 2002, the plant had treated 275 million gallons of groundwater and removed approximately 194 pounds of VOCs by filtering through activated carbon or by air stripping. The average total VOC concentration in influent at the plant has gradually declined, from about 105 μg/L in January 1999, to 53 μg/L in December 2002 (CH2M HILL, 2002e).

4.1.3 Interim Remedial Action

Table 4.1-2 presents the action and objectives selected for FT005, SS029, and SS030 in the IROD (Travis AFB, 1997).

TABLE 4.1-2
Sites FT005, SS049 and SS030 Action and Objectives Caption
Groundwater Five-Year Review, Travis Air Force Base, California

Alternative 3—Extraction, Treatment, and Discharge	
Site	**Objectives**
FT005	Migration Control at the Base boundary Offbase Remediation
SS029	Migration Control at the Base boundary
SS030	Source Control Migration Control at the Base boundary Offbase Remediation

4.1.3.1 Remedy Description

The SBBGWTP is designed to extract and treat groundwater from Sites SS030, FT005, and SS029 in the NEWIOU at Travis AFB. To date, the extraction system consists of six offbase extraction wells and a 200-foot onbase interceptor trench (EW 06x30) at Site SS030, six onbase extraction wells at Site FT005, and seven onbase extraction wells at Site SS029.

Figure 4.1-2 presents a process flow diagram for the GET system. After extraction, contaminated groundwater is conveyed to the SBBGWTP. The SBBGWTP uses a low-profile air stripper to remove VOCs from the extracted groundwater. A sequestering agent is added to the influent to prevent the precipitation and deposition of minerals in the air stripper. The SBBGWTP also has two LGAC vessels that are bypassed under normal operating conditions. The plant is configured so that either the air stripper or the LGAC treatment processes may be used, or the two processes may be used together in series or parallel operation (CH2M HILL, 2002d).

Vapor from the air stripper is discharged to the atmosphere. Mass loading to the atmosphere from this stream is well below the regulatory limits for emission control.

Treated groundwater meeting the discharge limits is discharged into Union Creek or is used for irrigation by an adjacent landowner. The quantity of water used for irrigation is entirely at the discretion of the landowner and is controlled by a valve located on the landowner's property (CH2M HILL, 2002d).

4.1.3.2 Implementation

The SBBGWTP was constructed during summer 1997, became operational in July 1998, and continues to operate and progress toward meeting cleanup goals at Travis AFB. Significant historical operational activities, changes, and additions include the following:

- July 1998 – The SBBGWTP was started on 6 July 1998, with three Site FT005 wells and the Site SS030 interceptor trench.
- September 1998 – The Site SS030 offbase wells, with the exception of EW711x30, were started 14 September 1998.
- 21 July 1999 – The San Francisco Bay RWQCB adopted Order Number 99-051. This order provides new general discharge requirement for discharge or reuse of extracted groundwater. Groundwater IRODs have been modified to incorporate the change (CH2M HILL, 2001c).
- Fall 2000 – The low-profile air stripper was installed at the SBBGWTP. Previously, extracted groundwater had been treated at the SBBGWTP with LGAC.
- September 2000 – EW711x30 was installed and brought online.
- February 2001 – At Site FT005, three additional onbase extraction wells (EW731x05, EW732x05, and EW733x05) were installed and brought online 28 February 2001.
- 3 December 2001 – A sequestering agent was approved for use by RWQCB to prevent scaling in the air stripper. It was added to the process beginning 3 January 2002.
- Summer 2002 to November 2002 – Nine additional wells were installed at FT005 to capture offbase contamination in the south Base area (locations are shown on Figure 4.1-1). See Section 4.2 for more information regarding the expansion (CH2M HILL, 2002d).

4.1.3.3 Operations

This section includes a discussion of O&M issues at the SBBGWTP and a description of current O&M, sampling, and monitoring activities. Throughout the operation of the SBBGWTP, the project team has identified O&M issues requiring modification of either the physical system or O&M procedures. Table 4.1-3 summarizes O&M issues and the corrective actions taken.

The plant is designed to operate unmanned, although some monitoring and maintenance are required to ensure proper operation. O&M labor requirements vary from month to month. Plant sampling is typically performed once a month. Specific sampling frequencies are described in the *SBBGWTP O&M Manual* (CH2M HILL, 2000b).

Plant monitoring is performed weekly in accordance with the *SBBGWTP O&M Manual* (CH2M HILL, 2000b). Monitoring consists of plant inspection and documentation of key system parameters (i.e., flow rate and pressures).

4.1.4 Groundwater Treatment

This section presents a summary of treatment system parameters and components, and a discussion of system performance metrics, discharge standards, and O&M costs and trends.

TABLE 4.1-3
SBBGWTP O&M Issues and Corrective Actions Taken
Groundwater Five-Year Review, Travis Air Force Base, California

Date or Period of Time	System Issue	Corrective Action Taken
November 1998 to March 1999	TCE detected in sample collected at the midpoint of the LGAC system.	Carbon in the lead vessel was replaced and the vessel was switched to the lag position (CH2M HILL, 1999c).
July 1998 to May 2000	Selenium and zinc concentrations were in excess of the discharge.	RWQCB discharge limits for inorganics were changed from concentration-based to mass-based effective 12 May 2000. The SBBGWTP effluent concentrations were below the new limits. Mass limits instead of concentration limits for inorganic compounds were implemented 12 May 2000. (CH2M HILL, 2001c).
Summer 2000	Expansion of the FT005 wellfield resulted in increased levels of 1,2-DCA in the plant influent stream, which is not efficiently treated with LGAC. This resulted in rapid breakthrough of the lead LGAC unit.	The LGAC System was replaced by the low-profile air stripper system beginning operation in December 2000 (CH2M HILL, 2001c).
December 2000 to January 2002	Within a month of operation, it was apparent that due to the naturally high mineral content of the groundwater at Travis AFB, the rate of scaling in the air stripper system was unacceptably high.	The low-profile air stripper system was brought offline in March 2001, and flow was switched to the LGAC unit pending RWQCB approval of a sequestering agent. During offline time, the extraction rate from the FT005 wells was reduced to approximately 30 percent of the design flow to ensure that the 1,2-DCA concentration in the influent was less than the discharge limit. Sequestering agent was approved for use beginning in January 2002 (CH2M HILL HILL, 2002f).
September 2001	Sump pump failure caused a release of lubricating oil to the system resulting in a Notice of Violation (CH2M HILL, 2002e)	Replacement of the submersible sump pump with aboveground, oil-free pump.
Prior to August 2002	Communication between the SS029 wellfield and the SBBGWTP was frequently lost.	The telemetry system was replaced in September 2002 (CH2M HILL, 2002d).
December 2002	Several of the flow sensors in the SS029 wellfield have begun to malfunction.	Sensors, having already outlived their expected service life, are in the process of being replaced (CH2M HILL, 2003b).

4.1.4.1 Treatment System Parameters and Components

Table 4.1-4 presents a summary of design and actual treatment system parameters for the SBBGWTP. As shown, influent concentrations at the SBBGWTP are very close to design values. The main differences are in the flow rate (current rate of 154 gpm versus design rate of 233 gpm) and TCE concentration (current concentration of 53 μg/L and design concentration of 33 μg/L).

The difference between design and actual flow rates exists because the FT005-offbase system has not yet been brought online. The air stripper at the SBBGWTP was designed to handle the anticipated flow from this area. Since the time of design, the anticipated flow has more than doubled, to the current estimate of 120 gpm. This estimate includes capacity for the extraction wells north of Creed Road and an additional 40 gpm of contingency for potential wells on the south side of Creed Road. The maximum hydraulic loading rate for the air stripper is 350 gpm. Based on estimated contaminant concentrations from the FT005-offbase wells, the air stripper is able to provide removal of VOCs from extracted groundwater to below detection limits, both at current and future influent concentrations.

TABLE 4.1-4
SBBGWTP Design and Actual System Parameters
Groundwater Five-Year Review, Travis Air Force Base, California

Parameter	Design	Actual[a]
Air Stripper		
Groundwater Flow Rate (gpm)	233	154
Air Flow Rate (scfm)	1,800	1,750
Influent Groundwater Contaminant Concentrations (µg/L)		
TCE	33	53
cis-1,2-DCE	2	2.6
1,2-DCA	1.7	0.37 J

[a]As of December 2002.

The difference between the design and actual TCE concentrations is also due to the fact that the FT005-offbase wells are not yet online. The flow from these wells will comprise approximately one third of the total flow to the SBBGWTP, and extracted groundwater from this area is anticipated to contain no detectable concentrations of TCE, as 1,2-DCA is the COC in this area. Low concentrations of VOCs from the FT005-offbase area will dilute the influent concentrations to the design level.

4.1.4.2 Performance Goals and Metrics

The performance metrics presented and discussed in this section are based on RPO strategies presented in Section 5.0 of the *LTO Strategic Plan* (CH2M HILL, 2001a) and in the RPO Handbook (U.S. Air Force, 1999).

The analyses presented in this section are also presented quarterly in the O&M reports and are designed to address the SBBGWTP effectiveness in meeting Travis AFB's four main objectives for onbase groundwater treatment facilities. Travis AFB's four main objectives are as follows:

1. Meet IROD cleanup goals
2. Reduce operating costs
3. Reduce time to cleanup
4. Maintain compliance with IROD discharge limits

The first and third objectives, to meet IROD cleanup goals and reduce time the cleanup, are discussed in this section. Reduction in operating costs is addressed in the cost evaluation presented in Section 4.1.4.5, and compliance with IROD discharge limits is addressed in Section 4.1.4.3.

At this time, the performance metrics presented in this section reveal few meaningful trends. This is due to the fact that the SBBGWTP has not yet been operated in a consistently steady manner for any length of time. Since its startup in 1998, the SBBGWTP has experienced variations in flow rate and mass loading due to addition of new wells and treatment plant and wellfield modifications. These conditions have also created variations in influent concentration, VOC mass removed, and treatment plant operating costs.

Completion of the offbase extraction system at FT005 in 2003 is anticipated to be the last major modification to the system, after which the SBBGWTP will begin steady-state LTO, and significant trends in performance metrics should begin to emerge.

Meet IROD Cleanup Goals. The IROD IRGs for the two main COCs in the SBBGWTP system are 5.0 µg/L for TCE and 0.5 µg/L for 1,2-DCA. Progress toward achieving these goals in groundwater can be evaluated through examination of trends in influent VOC concentration and mass removal rate over time.

- **Influent VOC Concentrations –** Influent VOC concentrations at the SBBGWTP are monitored monthly. Figure 4.1-3 presents the measured influent VOC concentrations over time from plant startup in 1998 to present. As shown on Figure 4.1-3, the total influent VOC concentration has fluctuated over time, with an overall decreasing trend. The influent VOC concentration has decreased by approximately 50 percent since plant startup 3 years ago in July 1998. The steady decline in influent VOC concentration can be attributed in part to both remediation progress and the dilution of the influent strea m with low concentration wells at Site FT005. The FT005 wells were installed to extract groundwater with relatively low 1,2-DCA concentrations (less than 10 µg/L) and little or no detectable TCE. These wells were brought online in December 2000. However, the fact that the mass removal rate (Figure 4.1-5) continues to decrease provides evidence that the decrease in inlet VOC concentration is at least partially due to remedial progress.
- **Mass Removal Rate –** As shown on Figure 4.1-4, the cumulative VOC mass removed by the SBBGWTP, since startup in July 1998, is approximately 195 pounds. The rate of VOC mass removal over time is presented on Figure 4.1-5. As shown, the mass removal rate has fluctuated between 0.02 and 0.23 pound of VOCs per day since plant startup. In general, the mass removal rate is decreasing with time.

Reduce Time to Cleanup. Reduction in time to cleanup may be achieved through regular review and optimization of system operating parameters.

To achieve reduction in the time to cleanup, extraction rates must be periodically adjusted to provide the greatest mass removal rate possible while maintaining hydraulic capture of plumes. Plant uptime must also be maximized. SBBGWTP progress, in terms of flow rate and plant uptime optimization are presented in this section.

- **Optimize Treatment Plant Flow Rate –** The average treatment plant flow rates and target flow rates from January 1999 to the present are presented on Figure 4.1-6. As shown, the total target flow rate for the SBBGWTP is currently 187 gpm. The highest actual flow rate at the SBBGWTP to date is 172 gpm in September 2002, when all wells were operating at their maximum flow rate. The target flow rate has never been achieved at the SBBGWTP because several extraction well locations are in areas less permeable than expected, and the wells are not able to sustain the design extraction rates.

- **Maximize Treatment Plant Uptime –** The percent uptime goal for all treatment plants at Travis AFB is 100 percent. While there are bound to be some unexpected shutdowns, with proper planning and maintenance, these occurrences can be minimized. The system uptime is determined by taking into account all factors that cause the plant to shut down. The SBBGWTP percent uptime is presented on Figure 4.1-7. In general, the percent uptime has remained close to 100 percent. The temporary decrease in uptime shown during early 2001 is due to the integration and startup of the expanded FT005 extraction system and air stripper.

4.1.4.3 Groundwater Discharge Standards

As presented in Section 3.1.4.2 for the NGWTP, all groundwater treatment plants at Travis AFB are required to comply with the substantive requirements of a National Pollutant Discharge Elimination System permit issued by the San Francisco Bay RWQCB. Specific requirements are described in RWQCB Order Number 99-051.

Treated water from the SBBGWTP is either discharged to Union Creek or conveyed to an offbase landowner's property for irrigation. During normal operation, system monitoring is performed weekly, and system sampling is performed monthly to ensure that the SBBGWTP is operating in compliance with groundwater discharge standards. Additional sampling and monitoring may also be conducted as needed. Data obtained through monitoring and sampling efforts are presented to the regulatory agencies monthly via the *SBBGWTP Monthly Data Sheet.*

The air stripper at the SBBGWTP has proven effective in removing VOCs from groundwater to below discharge standards, and typically below analytical detection limits. Since plant startup in 1998, RWQCB has issued only one Notice of Violation for the SBBGWTP. In September 2001, TPH-D was detected in the effluent in exceedance of the discharge limit. The source of the diesel-range compound was found to be the sump pump at the plant. The seal on this pump had failed, allowing lubricating oil from the motor housing to bleed into the SBBGWTP process stream. The pump was immediately replaced, and since that time there have been no detections of TPH-D anywhere in the plant.

There have been other exceedances of discharge limits at the SBBGWTP since startup, although other than the TPH-D incident described above, none of them led to the issuance of a Notice of Violation from the RWQCB. Before mass-based discharge limits were instituted in May 2000, several inorganic constituents, including selenium, lead, copper, and zinc were occasionally detected in the effluent at concentrations greater than the previous concentration-based limits. Since the adoption of mass-based limits, no exceedances of discharge limits have been observed.

In fourth quarter 2000, bis(2-ethylhexyl)phthalate was detected in the effluent at a concentration exceeding the discharge standard. The source of the contamination was found to be the ongoing construction at the SBBGWTP, particularly the installation of polyvinyl chloride piping around the air stripper. The detection was an isolated incident, and no Notice of Violation was issued. Subsequent sampling has confirmed that concentrations remain below detection limits and discharge standards.

4.1.4.4 Vapor Treatment Standards

The atmospheric emission of offgas from the air stripper at the SBBGWTP is subject to Regulation 8, Rule 47, of the BAAQMD; however, offgas from the air stripper at the SBBGWTP meets the criteria for an exemption from this rule for small operations, and therefore, treatment is not required.

4.1.4.5 Cost Evaluation

O&M costs for the SBBGWTP are tracked monthly and reviewed regularly to evaluate cost effectiveness of the system. Operating costs for the SBBGWTP reported in this section include the following components:

- Engineering
- O&M
- Performance monitoring (sampling and analysis)
- Reporting
- O&M manual preparation and periodic revision
- Project management and administration

The only project costs not included are electricity and Air Force project manager labor and expenses. Plant operating costs, operating costs per unit mass contaminants removed, and cumulative operating cost versus cumulative mass removed are presented and discussed in this section.

- **Operating Costs –** A 12-month rolling cost is used to evaluate trends in operating cost due to the high variability of costs from month to month. Over time, operating costs for groundwater treatment plants are expected to decrease as the system is optimized. The 12-month rolling average O&M cost for the SBBGWTP is $244,000 as of December 2002, and is presented as a function of time on Figure 4.1-8. As shown on Figure 4.1-8, the 12-month rolling average O&M cost for the SBBGWTP has continued to decline since system startup in 1998, and has decreased by approximately 25 percent over the last 3 years. This decrease is attributable to a number of improved efficiencies, including increased operator experience, improvements in communication and controls systems, and implementation of a sequestering agent injection system for the air stripper. For comparison, previous forecasts of annual O&M costs for the SBBGWTP range from a high of $538,000 in the FS (Radian Corporation, 1996a) to $250,000 per year in the *Remedial Action Strategic Plan* (Radian International, 1998a). Both previous cost estimates are based on assumptions that have since been superceded. For example, neither estimate anticipated the additional wells at FT005 and SS030 or the installation of the air stripper. Nevertheless, the actual cost is very close and currently slightly less ($244,000) than the estimate presented in the *Remedial Action Strategic Plan.*

- **Cost per Unit Mass Removed –** The cost per unit mass removed serves as another useful metric in evaluating the cost effectiveness of the remedy. The expected trend for this metric is an initial decrease (i.e., increase in plant efficiency) followed by an increase as operating costs remain at approximately the same level, and the rate of mass removal begins to decrease. The cost per pound of VOCs removed at the SBBGWTP is $7,966 as of December 2002, and is presented as a function of time on Figure 4.1-9. The cost per pound has increased 38 percent over the last 3 years of operation. Even though the operating costs have continued to decline (Figure 4.1-8), the cost per pound continues to increase as influent VOC concentrations and mass removal rates decrease. The mass removal rate has decreased by 40 percent over the last 3 years of operation.

- **Cumulative Operating Cost versus Cumulative Mass Removed –** Another performance metric, which may be used to evaluate the cost effectiveness of the remedy, is the cumulative operating cost versus the cumulative mass removed. A steep rise in this curve would indicate that the cost effectiveness of the system is rapidly decreasing, as would be the case if the operating costs remain constant and the mass removal rate decreases significantly. The cumulative operating cost versus the cumulative mass removed for the SBBGWTP is presented on Figure 4.1-10. As shown on Figure 4.1-10, the trend has been generally linear, and does not yet indicate any significant changes in the cost effectiveness of the system.

4.1.5 Groundwater Monitoring

The following sections summarize the hydrogeology of Sites FT005, SS029, and SS030 and provide the results of groundwater monitoring and modeling conducted in the vicinity of the FT005/SS029/SS030 GET systems (see Figure 4.1-11). A more comprehensive description of hydrologic and contaminant data collected at the sites is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2002a). Groundwater modeling performed in support of the five-year review is described in detail in Appendix A.

4.1.5.1 Site Geology

Sites FT005, SS029, and SS030 are located on a gently sloping grassy plain south of the runway. The depth to bedrock varies in the area. Site SS029 is bounded on the west by a submerged ridge of Markley Sandstone. This ridge likely extends to the south and bounds SS030 on its eastern side. Nortonville Shale, which forms the bedrock beneath SS029 and SS030, was eroded by ancient streams to form a small south-trending valley in the bedrock surface. Site FT005 is underlain by more resistant Domengine Sandstone. To the east of FT005, Nortonville Shale (on the eastern flank of the anticline shown on Figure 2-2) has been eroded to form a major south-southeast trending bedrock valley. The shale bedrock valley is bounded by Markley Sandstone on its eastern side.

The area of FT005/SS029/SS030 was subsequently overlain by alluvium as described in Section 2.1. At Sites SS029 and SS030, the alluvium is up to 60 feet thick (based on drilling).

At FT005, the alluvium is thinner, about 35 feet thick on average. The thickness of alluvium then generally increases to the southeast of FT005. The alluvium is composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay. Sand and silty sand were derived from nearby Markley and Domengine Sandstone. The distribution of alluvium at the sites is approximately as shown on Figure A-2 in Appendix A.

The main branch of Union Creek runs southwest across Site SS029 (see Figure A-3 in Appendix A).

4.1.5.2 Hydraulic Data and Modeling Results

The water table is approximately 10 to 18 feet bgs outside the area of active FT005/SS029/SS030 extraction wells. In the vicinity of groundwater extraction wells, the water table is up to 26 feet bgs. On a seasonal basis, the elevation of the water table varies from 2 to 5 feet. However, no long-term trends in the elevation of the water table have been observed outside the area of the extraction wells.

Figure 4.1-11 shows water table elevation contours at FT005, SS029, and SS030 during the May 2002 GSAP monitoring event. Figure 4.1-11 also shows the extent of hydraulic capture anticipated at the sites as a result of groundwater extraction (based on modeling performed during the design of active extraction wellfields) and the estimated extent of hydraulic capture occurring in 2001 (based on modeling performed during the five-year review). Vertical hydraulic gradients have been evaluated at FT005/ SS029/SS030 using groundwater level measurements in shallow and deep well pairs.

Table 4.1-5 presents conclusions based on hydraulic data and groundwater flow modeling near the FT005/SS029/SS030 groundwater extraction systems.

TABLE 4.1-5
Conclusions Concerning Hydrologic Conditions in the Area of FT005/SS029/SS030 GET Systems
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is approximately 10 to 18 feet bgs in the southeast part of Travis AFB, outside the area of active groundwater extraction. In the vicinity of groundwater extraction wells, the water table is up to 26 feet bgs.
2.	Regional groundwater flow is south to southeasterly.
3.	The direction and rate of groundwater flow varies across FT005/SS029/SS030, largely due to pumping at groundwater extraction wells. Lateral hydraulic gradients vary from about 0.004 foot/foot outside the area of extraction wells to more than 0.01 foot/foot near the extraction wells.
4.	The existence of inward gradients (converging flow) in the vicinity of extraction wells EW06x29 and EW07x29 at SS029 and EW04x30 at SS030 is well established by GSAP groundwater elevation measurements. Flow modeling conducted as part of the five-year review indicates that the zone of hydraulic capture created by SS029/SS030 pumping likely extends east to MW06x29 and MW09x30, and a minimum of 100 feet east of MW02x29; south to MW710x30 and MW708x30; approximately 100 feet west of MW02x30 and 350 feet west of MW1033x29; and north into the area of SS016 as shown on Figure 4.1-11.
5.	Based on groundwater elevation contours and flow modeling, onbase and offbase groundwater contamination above 5 µg/L at SS029/SS030 is being captured by groundwater extraction wells. In other words, the SS029/SS030 GET systems are achieving their design objective.
6.	Flow modeling indicates that the zone of hydraulic capture created by extraction at FT005 likely captures all of the contamination migrating offbase in this area.
7.	A new offbase groundwater extraction wellfield was installed at FT005 in 2002, and should capture offbase groundwater contamination at FT005 after it is brought online.
8.	Vertical hydraulic gradients vary across FT005, SS029, and SS030. Of the five shallow and deep well pairs at FT006/SS029/SS030, none showed significant vertical gradients (greater than ± 0.05 foot/foot) during the 2001-2002 GSAP.
9.	Groundwater discharge to Union Creek may occur in the vicinity of SS029. This reach of Union Creek flows year-round, although little to no runoff occurs in the area during the summer months. Additionally, an upward vertical hydraulic gradient of 0.01 foot/foot was observed at piezometer pair PZ01Sx29/PZ01Dx29 (adjacent to Union Creek) throughout 2001 and 2002.

4.1.5.3 Groundwater Quality Data

Figure 4.1-12 shows TCE concentrations detected in the May 2002 GSAP event at Sites FT005, SS029, and SS030; and Figure 4.1-13 shows 1,2-DCA concentrations detected at these sites. Figures 4.1-14 and 4.1-15 present time series plots of TCE and 1,2-DCA, respectively, over time at selected FT005/SS029/SS030 monitoring and extraction wells. Figure 4.1-12 shows the TCE distribution at SS029 and upgradient Site SS016. Based on water quality data, it appears that VOCs from SS016 may have migrated south to SS029.

The main objective of groundwater monitoring at GET sites at Travis AFB is to verify that Migration Control is being achieved. However, Sites FT005 and SS030 have the additional objective of groundwater remediation for the offbase portions of their plumes. Groundwater quality data collected from the monitoring network at FT005/SS029/SS030 support the conclusions summarized in Table 4.1-6.

4.1.5.4 Time to Cleanup

Simulations of contaminant migration and estimates of the time to clean contaminated groundwater are approximate. They reflect available information describing the distribution of groundwater contaminants (and sources) and rates and directions of groundwater flow through the aquifer (present and future), in addition to the inherent limitations of technologies available to simulate contaminant transport in aquifers. Consequently, estimates of cleanup time are mainly of qualitative or comparative value and should not be taken as exact times to clean contaminated groundwater. Despite these limitations, cleanup times for TCE-contaminated groundwater in the area of FT005/SS029/SS030 have been estimated to facilitate the evaluation of existing FT005/SS029/SS030 GET systems.

The migration of TCE-contaminated groundwater originating in the area of FT005/SS029/SS030, as well as contamination migrating south from SS016 (Sections 4.1.5 and 5.1.5), has been approximated using a series of mixing cell calculations simulating the flushing of uncontaminated groundwater through contaminated portions of the aquifer and extraction of contaminated groundwater by FT005/SS029/SS030 extraction wells. Series of mixing cells were aligned with flowtubes converging to the extraction wells for the purposes of the calculations. The configuration of flowtubes and rates of groundwater flow through flowtubes were based on the results of a steady simulation of groundwater flow performed using the updated Basewide Groundwater Flow Model (Appendix A). The initial (present-day) distribution of TCE at FT005/SS029/SS030 (and SS016) was estimated using groundwater quality data collected during the May 2002 GSAP monitoring event (Figures 4.1-12 and 5.1-12).

Simulations of TCE migration based on mixing cell (flushing) calculations are shown on Figure 4.1-16. The calculations suggest that TCE concentrations in the area of FT005/SS029/SS030 are likely to remain above 5 μg/L in excess of 100 years under current operating conditions. Figure 4.1-16 also indicates that TCE contamination may begin to migrate off-base south of SS029 in about 10 years. This process is shown to gradually increase over time, persisting all the way out to 100 years. However, the contamination is shown to be entirely captured by the offbase extraction system. The TCE contamination in the simulation originates from Site SS016, where capture is not occurring.

In contrast, time-to-cleanup estimates made during the FS predicted that TCE concentrations would reach 5 µg/L at FT005 in 15 years; SS029 in 149 years; and SS030 in 77 years (Radian Corporation, 1996b). Therefore, current modeling predicts that it will take longer to clean groundwater contamination at Sites FT005 and SS030. Partly these discrepancies reflect the inherent limitations of modeling, and partly the fact that the current model incorporates migration to these sites from upgradient Site SS016.

Figure 4.1-16 does not simulate the future effect of active groundwater extraction south of Site FT005. A new extraction system is planned for installation in 2003, which should have an impact on the hydrogeological system in the south Base area.

TABLE 4.1-6
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

Groundwater Quality Conclusions
1. Contaminant concentrations at SS029 and SS030 monitoring wells are generally stable or declining, indicating that the plumes are relatively stable and that the groundwater extraction systems are achieving capture. Examples of monitoring wells exhibiting decreasing TCE concentrations are shown on Figure 4.1-14 (MW1033x29, MW269x30, and MW04x30). Figure 4.1-14 also shows decreasing TCE trends in several extraction wells (EW03x29, EW07x29, EW03x30, EW04x30, and EW711x30). TCE concentrations detected at these extraction wells have dropped below the IRG (5 µg/L).
2. Two monitoring wells (MW1031x29 and MW03x30) have exhibited recent trends of increasing COC concentrations. TCE concentrations over time for both of these wells are presented on Figure 4.1-14. MW1031x29 is an upgradient SS029 well, and increasing concentrations at this location may be due to VOC migration from the upgradient SS016 plume. Figure 4.1-17 shows the distribution of TCE contamination at SS029 and upgradient Site SS016. The extraction system at SS029 should capture any groundwater contamination migrating south from SS016.
3. The reason for the increasing TCE concentrations at monitoring well MW03x30 is unclear. However, groundwater modeling results indicate that groundwater in the vicinity of MW03x30 will be captured by the GET. Extraction wells in the vicinity of this monitoring well (EW01x30, EW02x30, and EW05x30) should continue to be operated at design capacity as long as COC concentrations continue to increase in this monitoring well.
4. Samples collected from MW708x30, in the southernmost region of the offbase plume at SS030, had historically contained low TCE concentrations. However, TCE was not detected in 2002 in samples from wells MW708x30, MW709x30, and MW710x30, which are located south (downgradient) of new extraction well EW711x30. Additionally, TCE concentrations in EW711x30 have been decreasing, as shown on Figure 4.1-14. TCE has not been detected in the domestic well (DWSET1x30) located downgradient of MW708x30. These data indicate that the extraction system is capturing and remediating the offbase portion of the plume at SS030.
5. Extensive FT005-offbase plume characterization was performed during summer 2002, and the plume is now known to extend approximately 2,700 feet south of the Base boundary. Several new monitoring wells and extraction wells were installed offbase in the summer and fall of 2002 as part of this investigation. GSAP data indicate that the 1,2-DCA plume is being captured in the onbase area. 1,2-DCA concentrations are stable in FT005 monitoring wells, although they are increasing in a few extraction wells (Figure 4.1-15).
6. 1,2-DCA concentrations in extraction well EW731x05 have been decreasing (Figure 4.1-15) and are now below the IRG (0.5 µg/L). 1,2-DCA concentrations in monitoring well MW738x05, located downgradient of EW731x05, remain below the IRG. 1,2-DCA was the only COC detected in either of these wells.
7. Although Union Creek appears to be a gaining stream, the low concentrations of TCE and other VOCs observed at the five surface water sampling stations located along the stream indicate that groundwater contamination is not significantly impacting the water quality of the stream. Although TCE was detected at concentrations greater than 100 µg/L in groundwater samples next to the creek at Site SS029, TCE concentrations in Union Creek at this location are less than 1 µg/L. Upstream at Outfall 3, TCE concentrations have decreased significantly since 1999.

The results presented are based on the existing configuration of extraction wells at FT005 / SS029 / SS030, designed to control the migration of contaminated groundwater in the area of FT005 / SS029 / SS030, rather than accelerate cleanup. System optimization, including the installation of additional extraction wells to capture contamination migrating south from SS016, will reduce cleanup times.

The results presented represent best estimates of possible outcomes over long periods of time under current operating conditions, and are provided as a potential basis for identifying and prioritizing areas of future investigation. These results are based on recent refinements to the Basewide Groundwater Flow Model (Appendix A). However, these are only estimates and will not necessarily take place. They are one possible future outcome if no further actions are taken, and should be verified and evaluated over time using GSAP and other field data.

Long-term monitoring will be vigilant to the possibility that contamination from SS016 may not be captured by the extraction systems at SS029 and FT005. If this actually occurs, then in the future it may be necessary to expand the existing system or install some other technology to capture and treat the contamination before it reaches the Base boundary. Because of the slow movement of groundwater, there will be time to react and program the funds needed to address the problem. At present, there is no indication that this is happening.

4.1.6 Opportunities for Optimization

Opportunities for optimization, either in terms of reduced time to cleanup or reduced O&M cost, for the SBBGWTP are identified in this section. The following potential areas for optimization are evaluated:

- Extraction well flow adjustments to increase mass removal rate and decrease O&M cost while maintaining IROD objectives
- Modification of ex situ treatment systems to reduce O&M cost
- Implementation of in situ technologies to reduce time to cleanup

Each potential area for optimization is discussed briefly in the following sections. Table 4.1-7 summaries the opportunities for optimization discussed below.

TABLE 4.1-7
Recommendations for Optimization at Sites FT005, SS030, and SS029
Groundwater Five-Year Review, Travis Air Force Base, California

Recommendations for Optimization
1. Use groundwater modeling to reduce pumping in existing extraction wells and potentially stop pumping altogether in existing extraction wells.
2. Use groundwater modeling to identify locations for one or more new extraction wells that are closer to source areas, or to prevent further southward migration of contamination from SS016.
3. Install additional monitoring wells if necessary to monitor the performance of new extraction wells.
4. Consider in situ technologies to reduce source area contaminant mass.

4.1.6.1 Extraction Well Flow Adjustment

It might be possible to reduce the number of extraction wells in operation or modify the pumping rates and still achieve the Source Control objective. As noted above, contaminant concentrations have deceased dramatically since the extraction system has been in operation. Groundwater modeling should be used to assess the potential impact of changes in extraction rates and/or shutting down extraction wells altogether.

Areas for consideration of extraction well flow adjustment at the SBBWTP include the following:

- **SS030 –** Reduce or shut off flow from wells EW03x30, EW04x30, and EW711x30. Each of these extraction wells, and the monitoring wells around them, have TCE concentrations less than the MCL of 5 µg/L, and have exhibited strong downward trends over time. It might be possible to shut these wells down for a rebound study, leaving EW05x30 as the southernmost well. Groundwater monitoring would continue, and extraction could be restarted if necessary.
- **SS029 –** Reduce or shut off flow from wells EW03x29 and EW07x29. Each of these extraction wells, and the monitoring wells around them, have TCE concentrations less than the MCL of 5 µg/L and have exhibited strong downward trends over time. It may be possible to shut these wells down for a rebound study. Both of these wells are located on the periphery of the contaminant plume and, now that concentrations have dropped below the MCL, their operation could be counter-productive to source area mass removal. Groundwater monitoring would continue, and extraction could be restarted if necessary.
- **FT005 –** The concentration of 1,2-DCA in EW731x05 and nearby monitoring well MW738x05 have always been relatively low and remain below the MCL of 0.5 µg/L. In addition, TCE was not detected in either well. Well EW731x05 is located on the edge of the plume boundary, and well shutoff should not have a detrimental effect on overall capture of the contaminated area. A rebound study for this well is recommended.

4.1.6.2 Installation of Additional Extraction Wells

The objectives of the SBBGWTP are mass removal for the offbase sites (portions of FT005 and SS030) and Migration Control for the onbase sites (SS029 and portions of FT005 and SS030). The GET system is successfully achieving this objective. However, as discussed above, contaminant concentrations have declined at the south Base boundary sites, and the extent of groundwater contaminated above IRGs is much more restricted. Ongoing extraction at lower and lower concentrations will gradually become more expensive (see Section 4.1.4.5) on a cost per pound basis. In addition, it will require a long time to achieve IRGs across the entire site.

Installation of additional extraction wells near the SS029, SS030, and possibly the FT005 source areas will allow for more efficient Source Control as the zone of contamination shrinks inward, and will also decrease the overall time required to achieve IRGs. Groundwater modeling should be used to identify the optimal locations for these wells.

However, a qualitative assessment indicates that the following additional extraction wells would be helpful:

- **SS030 –** Installing an additional well in the high concentration area near MW03x30, where concentrations have been increasing, could increase the rate of mass removal rate from SS030.
- **SS029 –** Installing an additional well in the high concentration area near MW1033x29 could increase the mass removal rate from SS029.
- **FT005 –** The mass removal rate might be increased by installing an additional well in the area of highest concentration, near EW02x05.

4.1.6.3 Installation of Additional Monitoring Wells

Additional monitoring wells may be needed if new extraction wells are installed.

4.1.6.4 Modification of Ex Situ Treatment System

The groundwater treatment train is well optimized, and no modifications are needed at this time. Air stripping is a cost-effective technology for the flow rates and contaminant concentrations at the SBBGWTP.

4.1.6.5 Implementation of In Situ Technologies for Mass Removal

In situ technologies have the potential to decrease the time to cleanup, if implemented in the south Base boundary area, and include the following:

- **Enhanced Bioremediation –** This technology is potentially effective for TCE contaminant plumes at SS030 and SS029, but not for the 1,2-DCA plume at FT005, because this compound is not readily biodegradable. Enhanced bioremediation can comprise a number of strategies, but generally consists of the injection of an electron donor into the subsurface to stimulate biological reductive dechlorination. Possible amendment solutions include, but are not limited to, Hydrogen Release Compound (HRC®), lactate, and Edible Oil Substrate (EOS™). The selected amendment could be injected into high-concentration areas using direct-push injection points. The injection system would be temporary. The existing extraction system would aid in the distribution of the amendment in the subsurface. Site-specific technology effectiveness would need to be evaluated through bench-scale microcosm tests.

- **In Situ Oxidation –** Chemical oxidation involves injecting a solution of a strong oxidizing agent, such as Fenton's Reagent, permanganate, or hydrogen peroxide, into a high-concentration zone to destroy COCs in situ. This technology is potentially effective for both TCE and 1,2-DCA, and therefore could be applied to all sites in the SBBGWTP area. Site-specific technology effectiveness would need to be evaluated through bench- and pilot-scale tests. The cost per treated area for this technology is relatively high; therefore, application is best suited to high-concentration source areas.

Implementation of any of the above technologies would increase short-term costs but, through reduction in time to cleanup, could substantially decrease total costs for site cleanup. Further investigation and pilot-scale tests would be needed prior to implementation of either technology.

4.1.7 Technical Assessment

4.1.7.1 Is the Remedy Functioning as Intended by the IROD?

Yes. Groundwater data and modeling results indicate that Migration Control is being achieved along the Base boundary for FT005, SS029, and SS030, and in the offbase portion of SS030. In addition, groundwater remediation is occurring successfully in the offbase portion of SS030. At these sites, the remedial action is functioning as designed, containment and cleanup are being achieved, and ongoing monitoring is confirming the protectiveness of the remedy. O&M costs are declining, and the newly installed air stripper successfully treats the groundwater VOCs at the sites.

An offbase extraction system has been designed for FT005, and construction began in 2002. This expansion should go online in 2003. Future monitoring will assess the effectiveness of groundwater remediation in that area. Each year, the Annual GSAP Reports will summarize the data collected in the offbase portion of FT005, draw conclusions regarding whether the contamination is being successfully captured, and offer recommendations to address any deficiencies or issues observed in the performance of this system.

4.1.7.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are currently no exposure pathways to potential human or ecological receptors. Ongoing monitoring in the nearest domestic well at SS030 has not revealed any contamination. As long as an IROD governs remedial actions at Travis AFB, IRGs remain valid as cleanup levels.

4.1.7.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. The remedy at FT005, SS029, and SS030 appears to be effective and protective to date. This protectiveness should extend to the offbase portion of FT005 after the expanded extraction system goes online.

4.1.8 Statement of Protectiveness

The GET remedy at Sites FT005 (onbase), SS029, and SS030 is expected to be or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

4.1.9 References

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Figure
4.1-1 FT005/SS029/SS030 Site Map
11 x 17 color

Figure 4.1-1 continued

Figure
4.1-2 SBBGWTP Process Flow Diagram
11 x 17 b&w

Figure 4.1-2 continued

Figure
4.1-3 SBBGWTP Influent VOC Concentration over Time
8.5 x 11 b&w

Figure
4.1-4 SBBGWTP Cumulative VOC Mass Removed over Time
8.5 x 11 b&w

Figure
4.1-5 SBBGWTP VOC Mass Removal over Time
8.5 x 11 b&w

Figure
4.1-6 Average SBBGWTP Flow Rates and Target Flow Rates, January 1999 through Present
8.5 x 11 b&w

Figure
4.1-7 Monthly SBBGWTP Percent Uptime, January 1999 through Present
8.5 x 11 b&w

Figure
4.1-8 SBBGWTP Rolling 12-month Average Operating Costs
8.5 x 11 b&w

Figure 4.1-9 SBBGWTP Rolling 12-month Average Cost per Pound of VOCs Removed

8.5 x 11 b&w

Figure
4.1-10 Cumulative Operating Costs versus Cumulative Pounds of VOCs Removed
8.5 x 11 b&w

Figure
4.1-11 Groundwater Elevations Measured at FT005, SS029, and SS030 during May 2002
11 x 17 b&w

Figure 4.1-11 continued

Figure
4.1-12 TCE Distribution at FT005, SS029, SS030
11 x 17 color

Figure 4.1-12 continued

Figure
4.1-13 1,2-DCA Distribution at FT005, SS029, SS030
11 x 17 color

Figure 4.1-13 continued

Figure
4.1-14 TCE Chemical Time Series Plots for FT005/SS029/SS030
8.5 x 11 b&w

page 1 of 2

Figure 4.1-14 Page 2 of 2

Figure
4.1-15 1,2-DCA Chemical Time Series Plots for FT005/SS029/SS030
8.5 x 11 b&w

Figure
4.1-16 Time to Cleanup Simulation for TCE at FT005/SS029/SS030
11 x 17 color

Figure 4.1-16 continued

Figure
4.1-17 TCE Distribution at Sites SS016 and SS029
11 x 17 color

Figure 4.1-17 continued

4.2 FT005-offbase Expansion

4.2.1 Update

The FT005-offbase expansion project is partially complete at this time. Nine extraction wells and 16 monitoring wells have been installed and sampled. Installation of extraction well vaults and a conveyance pipeline to convey extracted groundwater to the SBBGWTP for treatment is planned for spring 2003. Upgrades to the SBBGWTP to accommodate the additional flow and contaminant mass loading from the FT005-offbase area were completed in 2000. The offbase extraction system should be operational in summer 2003.

This section provides a brief summary of site history and status of the FT005-offbase project. Additional site information is provided in Section 4.1.1. Both the on- and offbase FT005 expansion projects are detailed in the *FT005 Interim Groundwater Remedial Design Report* (CH2M HILL, 2000d).

The onbase project was completed in 2000. The offbase expansion project was originally planned for 2000, but was delayed pending finalization of a land easement agreement with the offbase landowner. The project was delayed for nearly 2 years, but by spring 2002, the easement agreement was in place, and preparations for construction of the offbase system resumed.

The site characterization activities used to support the original offbase extraction system design were conducted in the fall of 1999. By the time access was granted for implementation in 2002, three years had passed since any hydraulic or chemical data had been collected in the area. Therefore, prior to implementation of the design, a limited investigation was performed using cone penetrometer testing to confirm that the nature and extent of contamination had not changed significantly. The results of this cone penetrometer testing investigation were used to update the conceptual model for the site and revise the extraction system design to ensure hydraulic capture of contaminated groundwater.

In total, 24 locations in the offbase area were sampled using cone penetrometer testing. Samples were collected from two different depths at each location; the first in the most shallow water-bearing zone (typically around 30 feet bgs), and the second in the next deepest major water-bearing zone (typically 50 to 70 feet bgs). The results of the cone penetrometer testing investigation were used to estimate the extent of contamination in the offbase area and prepare the revised extraction system design. The extent of 1,2-DCA contamination at FT005, as determined by the 2002 cone penetrometer testing investigation, is presented on Figure 4.2-1.

Well installation, including 9 extraction wells and 16 monitoring wells, was completed in November 2002. The location of new extraction and monitoring wells and the planned routing of the multi-service trench are shown on Figure 4.1-1.

All new wells were sampled for VOCs. The only compound detected in the FT005-offbase area in excess of the California MCL was 1,2-DCA. The MCL for 1,2-DCA is 0.5 μg/L. Concentrations of 1,2-DCA in the offbase area ranged from nondetect to 1.8 μg/L (CH2M HILL, 2002e).

After the new extraction system is completed and goes online, it is anticipated that capture and remediation of the 1,2-DCA contamination will be achieved. Additional future investigation may be necessary south of the current design to confirm that 1,2-DCA has not migrated beyond the current design capture zone.

4.2.2 Statement of Protectiveness

The GET remedy at Site FT005 (offbase) is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

4.2.3 References

CH2M HILL. 2002e. Technical Memorandum: *FT005 Offbase IRA, Current Status.* Travis AFB, California. December.

CH2M HILL. 2000d. *FT005 Interim Groundwater Remedial Design Report.* Travis AFB, California.

Figure 4.2-1 FT005-offbase Extent of 1,2-DCA

11 x 17 color

Figure 4.2-1 continued

SECTION 5.0

Central IRA Area

5.1 SS016/ST032 Groundwater Extraction and Treatment System

5.1.1 Site Description

Site SS016 occupies 210 acres near the Base Control Tower and runway in the center of the EIOU. Site ST032 occupies 22 acres adjacent to and east of Site SS016 in the runway vicinity. Because of the proximity of Sites SS016 and ST032 to each other, including the potential mixing of contaminated groundwater, the sites are addressed together. Figure 5.1-1 shows the locations of buildings, roads, runways, and monitoring and extraction wells at Sites SS016 and ST032.

The following potential sources of groundwater contamination have been identified at Site SS016:

- OSA (vicinity of Facility 18)
- Facility 11
- Facility 13/14
- Facility 20 (Base Control Tower)
- Facility 42/1941
- Facilities 139/144
- Storm sewers located in the Storm Sewer Right-of-Way (SSRW)

The OSA is located in the vicinity of Facility 18 south of Hangar Avenue and east of Broadway Street. Waste oils and solvents were disposed of and/or accidentally released at Facility 18 during past cleaning and degreasing operations. At one time, the facility (a cleaning and degreasing shop) included a washrack, OWS, and subsurface open-top concrete tank. Use of the OWS and open-top tank were discontinued in 1985. The OWS and tank were removed in 1997 (Roy F. Weston, Inc., 1995).

Facility 11 is located between Hangar Avenue and the flightline, west of Burgan Boulevard. Flightline support equipment has been serviced and repaired at Facility 11 since 1944. Small amounts of hydraulic fluids and oils are used during these activities. According to interviews with shop personnel, past operations at the facility included the accumulation of hazardous wastes and use of solvents to clean aircraft engines. No spills have been documented at Facility 11 (Roy F. Weston, Inc., 1995).

Facility 13/14, formerly located south of Hangar Avenue between old hangars 13 and 14, was used as a washrack from the mid-1950s to mid-1960s. The facility was demolished in 1988 and replaced by Building 31 (Roy F. Weston, Inc., 1995).

Facility 20, the Base Control Tower, is located southeast of the intersection of Burgan Boulevard and Hangar Avenue. An underground tank was used to store fuel for a backup generator in the area. The underground storage tank was removed in 1994 (Roy F. Weston, Inc., 1995).

Facility 42/1941 is located near Facility 11 between Hangar Avenue and the flightline. The facility has been used to wash aircraft and store fuel and waste oils. Four 250-gallon above-ground storage tanks store fuel and waste oils at the facility. The washrack is connected to an OWS, which discharges to the sanitary sewer (Roy F. Weston, Inc., 1995).

Facilities 139/144 are located south of Hickam Avenue and east of Broadway Street (see Figure 5.1-1). The facilities were constructed in 1954 and 1945, respectively, to perform vehicle maintenance, including bodywork, painting, and radiator cleaning. A leaking, 2,000-gallon underground storage tank containing solvent was removed from the area in 1985. Floor drains in the shop at Facility 139 are connected to two OWSs. Past operations at Facility 144 included surface disposal of radiator test tank fluid (Roy F. Weston, Inc., 1995).

Several storm sewers are located in an SSRW north and south of Hangar Avenue. Sewer lines traversing Site SS016 carry stormwater from area parking lots and aircraft aprons, as well as industrial areas in the EIOU. A video camera was used to inspect storm sewers in this area in 1988. The lines were generally found to be in good condition. However, some cracks, roots, and mineral deposits were observed in the storm sewer lines that could be indicative of groundwater infiltration and/or leakage of stormwater into surrounding soils. Additionally, leaks may have occurred from underground fuel lines in the SSRW in the past (Roy F. Weston, Inc., 1995).

Site ST032 consists of two open, grassy areas surrounded by runway and taxiway pavement. Two plumes of contaminated groundwater have been identified in the area: Plume A between Taxiway H and the aircraft parking apron (northern portion of the site) and Plume B between Runway 21R and Taxiway R (the southern portion of the site). Both fuel and TCE contamination have been detected in the area of Plume A. TCE contamination at Site ST032 is believed to have originated at Site SS016. Plume B is limited to fuel contamination. Past leakage from an underground jet-fuel line is the suspected source of fuel contamination in the area. No estimate of the volume, period, or location(s) of suspected fuel line release(s) is available (Radian International, 1997). Floating product has been observed intermittently in well MW246x32 in the southern portion of the site. Table 5.1-1 lists COCs at Sites SS016 and ST032.

TABLE 5.1-1
Chemicals of Concern at Sites SS016 and ST032
Groundwater Five-Year Review, Travis Air Force Base, California

	SS016	ST032
COCs at Individual Sites	cis-1,2-DCE, vinyl chloride, chloroform, 1,4-dichlorobenzene, dichlorobromomethane, 1,2-DCA, PCE, nickel	Xylenes
COCs at Both Sites	TCE, benzene, bis(2-ethylhexyl)phthalate, 1,1-DCE	

Source: Travis AFB, 1997.

Note:

PCE = tetrachloroethylene

5.1.2 Site History and Status

Site SS016 has been the object of RIs from the beginning of the IRP at Travis AFB. The following investigations have taken place at Sites SS016 and ST032:

SS016 (Formerly OSA; SSRW; and Facilities 11, 13/14, 20, and 42/194)

- The OSA and SSRW were identified as potentially contaminated sites during the IRP Phase I Records Search (Engineering Science, Inc., 1983).
- The IRP Phase II Confirmation/Quantification Stage 1 investigation was performed in 1984 and 1985. The OSA and SSRW were both investigated as follows (Roy F. Weston, Inc., 1986):

  OSA – Installation of two monitoring wells (MW-102 and MW-103) and collection of subsurface soil samples

  SSRW – Installation of six monitoring wells (MW-107 through MW-112) and collection of surface water, sediment, and groundwater samples
- An IRP Stage 2 investigation was performed at the OSA and SSRW in 1988 as follows (Roy F. Weston, Inc., 1990):

  OSA – Installation of six monitoring wells (MW-211, MW-212, MW-213, MW-214, MW-226, and MW-305) and collection of subsurface soil, soil gas, and groundwater samples

  SSRW – Collection of soil gas, surface water, sediment, and groundwater samples
- A RCRA Facility Assessment was performed in 1991. Several other SS016 sites were identified for future investigation at this time, including Facilities 11, 13/14, 20, and 42/1941. Both the OSA and SSRW were investigated during the RCRA Facility Assessment as follows (Roy F. Weston, Inc., 1992):

  OSA – Installation of five more monitoring wells in the OSA (MW-239 through MW-243) and collection of surface soil samples

  SSRW – Installation of four more monitoring wells (MW-244, MW-245, MW-246, and MW-316)
- The facilities at SS016 were investigated for the first time in 1992, following the RCRA Facility Assessment (Roy F. Weston, Inc., 1992), and included the following:

  Facility 11 – Installation of one monitoring well (MW-1206) and collection of soil samples

  Facilities 13/14 and 20 – Installation of one monitoring well (MW-1207) and collection of soil samples

  Facilities 42/1941 – Collection of soil samples
- The RI was performed between 1993 and 1995. Investigation activities included the following (Roy F. Weston, Inc., 1995):

  OSA – Installation of a monitoring well (MW-327) and collection of surface soil, sub-surface soil, and groundwater samples

SSRW – Installation of seven monitoring wells (MW-1012, MW-1013, MW1020, MW-1022, MW-1023, MW-328, and MW329) and collection of surface soil, subsurface soil, surface water, sediment, and groundwater samples

Facility 11 – Installation of monitoring wells (MW-1700, MW-1701, MW-1702, MW-1703, and MW-1732) and collection of subsurface soil and groundwater samples

Facilities 13/14 – Installation of monitoring wells (MW-1704, MW-1705, MW-1706, and MW-1733) and collection of subsurface soil and groundwater samples

Facility 20 – Installation of monitoring wells (MW-1207, MW-1707, MW-1708, MW-1709, MW-1734, MW-1735, and MW-1747) and collection of surface soil, subsurface soil, and groundwater samples

Facilities 42/1941 – Installation of monitoring wells (MW-1710, MW-1711, and MW-1736) and collection of subsurface soil and groundwater samples

- The TARA began operating in May 1995. The system was designed to treat VOC-contaminated soil vapor and groundwater, and consisted of two 600-foot horizontal extraction wells. As operated, the TARA treated groundwater through granular-activated carbon and discharged to irrigation or the storm sewer (Roy F. Weston, Inc., 1995).

ST032 (Formerly the MW-107 and MW-246 areas)

- Wells MW-107 and MW-246 were originally installed as part of SSRW investigations. However, these locations were treated as unique study areas for the first time in 1994, in the late stages of the RI in the EIOU. Activities included the following (Roy F. Weston, Inc., 1995):
  - MW-107 Area – Installation of monitoring wells (MW-1026, MW-1027, and MW-1028) and collection of groundwater samples
  - MW-246 Area – Installation of monitoring wells (MW-1024 and MW-1025) and collection of subsurface soil and groundwater samples

SS016 and ST032

- The RI recommended that both SS016 (OSA; SSRW; and Facilities 11, 13/14, 20, and 42/1941) and ST032 (MW-107 and MW-246 areas) be carried forward to the NEWIOU FS (Roy F. Weston, Inc., 1995).
- The FS evaluated alternatives for remediating these sites (Radian Corporation, 1996a).
- The *Groundwater IROD for the NEWIOU* identified the following remedial alternatives for the sites (Travis AFB, 1997):
  - SS016 – Groundwater extraction, treatment, and discharge to achieve Source Control and Migration Control; and MNA for the remainder of the plume
  - ST032 – MNA and free-product removal
- Collection of groundwater samples as part of the GSAP has been performed from 1996 to the present (CH2M HILL, 2002a).

The Migration Control objective in the southern portion of SS016 is being implemented by capture at the SS029 GET system. The SS016 and SS029 plumes are commingled, and the presence of the active runway prevents additional groundwater extraction in that area. Similarly, the MNA objective is being addressed through active monitoring. Groundwater contamination that migrates will be captured farther south (CH2M HILL, 2001d).

A total of 182 million gallons of contaminated groundwater have been treated at the CGWTP through 31 December 2002. From January 1996 to 31 December 2002, the CGWTP has removed an estimated VOC mass of 2,384 pounds. Of the 2,384 pounds of VOC removed, approximately 1,048 pounds were removed from vapor (URS Group, 2002d).

5.1.3 Interim Remedial Action

Table 5.1-2 lists the actions and objectives that were selected for SS016 and ST032 in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997).

TABLE 5.1-2
Selected Interim Actions at SS016 and ST032
Groundwater Five-Year Review, Travis Air Force Base, California

Site	Monitored Natural Attenuation	Groundwater Extraction and Treatment	
		Source Control	Migration Control
SS016	X[a]	X[b]	X[c]
ST032	X[a]	X[d]	

[a]MNA later eliminated as an interim action at these sites.
[b]Source Control defined in the IROD as 3,000 µg/L. The SS016 GET designed to 1,000 µg/L.
[c]Migration Control later eliminated as an interim action at SS016.
[d]Source Control by free-product removal.

Operation of a passive hydroskimmer addressed the floating product historically observed at ST032. Measurable amounts of floating product were not observed at ST032 during the 2001-2002 GSAP.

5.1.3.1 Remedy Description

The CGWTP uses a UV/Ox system and activated carbon vessels to remove VOCs from extracted groundwater. The process is presented on Figure 5.1-2, and is described below.

Groundwater treated at the CGWTP is pumped from the following sources into a 5,000-gallon influent holding tank:

- Two extraction wells (EW01x16 and EW02x16), located in the TARA, are connected directly to the CGWTP.
- Four extraction wells (EW03x16, EW605x16, EW610x16, and the 2-Phase® extraction well) located in the OSA are connected to the CGWTP via the ThOx system.
- The WTTP, which extracts water from 24 wells in the WIOU and WABOU, also transfers water to the CGWTP.

The water in the influent holding tank is mixed with hydrogen peroxide, then passed through two UV/Ox skids for treatment. The water is filtered before flowing through two 20,000-pound activated carbon vessels operated in series, ensuring removal of the VOCs. As an added safety feature, three 2,000-pound activated carbon vessels are also installed downstream of the two 20,000-pound vessels operating in parallel. After carbon treatment, the water is piped to a 500,000-gallon water tank and discharged for irrigation during summer months and to the stormdrain during the winter (URS Group, 2002e).

5.1.3.2 Implementation

The CGWTP at SS016 has been in operation since 1995. The following are milestones in the operation of this plant:

- The original TARA consisted of two horizontal extraction wells. Groundwater from the wells was treated through granular-activated carbon and discharged to irrigation or the storm sewer.
- The TARA was expanded in 1996 by adding an additional horizontal extraction well and a 2-Phase® extraction well near the OSA source area. Soil vapor from the 2-Phase® well was treated by ThOx.
- The WTTP was brought online on 01 February 2000, and is designed to pump water to the CGWTP for treatment from 24 extraction wells in the WIOU (from Sites SD033, SD034, SD036, and SD037) and the WABOU (from Sites DP039, SD041, SD043, and LF008). The WTTP contributes about 40 to 45 gpm to the total CGWTP flow (URS Group, 2002f).
- Two additional dual-phase groundwater extraction wells were installed 500 feet and 1,500 feet downgradient (southeast) of the OSA in April 2001 (EW610x16 and EW605x16). These two additional extraction wells were brought online 30 August 2001. Seven monitoring wells were also installed at that time to assess the effectiveness of the extraction system.
- In February 2001, one DPE well from DP039 (EW563x39) was brought online (URS Group, 2002f).
- On 30 March 2001, the original Alzeta ThOx at the 2-Phase® extraction system was replaced with a new King Buck Technology Thermal Oxidizer™. Currently, four wells are connected to the system, including one 2-Phase® extraction well, one horizontal DPE well, and two new vertical DPE wells. Groundwater extracted by the ThOx system is routed to the CGWTP for treatment; extracted vapor is treated locally using ThOx (URS Group, 2002f).
- In June 2001, three extraction wells from LF008 (EW719x08, EW720x08, and EW721x08) were brought online. These wells contribute 1 to 3 gpm to the CGWTP flow via the WTTP (URS Group, 2002f).

On 18 June 2002, the burner at the ThOx system failed. Because of recurrent failures in the ThOx system over the previous months, the Air Force decided to leave the unit offline and assess whether it would be cost effective to restart it. At the same time, the Air Force decided to perform a rebound study to observe whether vapor concentrations increase. If so, the ThOx system may be replaced with a VGAC unit (URS Group, 2002g).

A passive hydroskimmer operated in MW246x32 at Site ST032 between 1998 and 2002. Approximately 0.5 gallon of floating product was removed during that time. Most of this removal occurred in 1998. Floating product has been observed only intermittently since that time in MW246x16, and no floating product has been observed in nearby well MW1024x32. Because the passive hydroskimmer never yielded much floating product, and floating product has not been detected at thicknesses greater than 0.01 foot in over 2 years (floating product was not detected at all in 2001), the passive hydroskimmer was removed from this well in September 2002.

5.1.3.3 Operations

This section includes discussion of O&M issues at the CGWTP and description of current O&M, sampling, and monitoring activities. Throughout the operation of the CGWTP, the project team has identified O&M issues requiring modification of either the physical system or O&M procedures. Table 5.1-3 summarizes O&M issues and the corrective actions taken.

TABLE 5.1-3
CGWTP O&M Issues and Corrective Actions Taken
Groundwater Five-Year Review, Travis Air Force Base, California

Date or Period of Time	System Issue	Corrective Action Taken
2001	No violations of discharge requirements occurred during 2001 (URS Group, 2002f).	
12 April 2002	A Notice of Violation was administered as a result of a spill at the WTTP following a power outage on the west side of the Base. The combination CGWTP continued to operate (no power failure), and the mechanical failure of the check valve at the WTTP effluent transfer pump allowed water from the CGWTP to flow in reverse and back through the re-circulation tank. Continuous backflow caused the re-circulation tank to overflow into the containment area and onto the lawn south of the WTTP (URS Group, 2002g).	On 13 April, the backflow from SS016 wells was stopped by shutting the valve on the transfer line from the WTTP to the CGWTP. Check valves on both effluent transfer pumps were replaced with valves containing stainless-steel parts not susceptible to corrosion. A 4-inch polyvinyl chloride ball check valve was installed after the WTTP effluent transfer pumps as an added redundancy (URS Group, 2002g).
June 2002 - Third Quarter 2002	The burner at the ThOx system failed on 18 June 2002, because the knitted metal fiber burner cover had corroded (URS Group, 2002g).	Due to a decrease in the influent vapor concentrations, it was recommended that the ThOx system remain offline to determine if it is necessary or cost effective to continue its operation. A 3-month rebound study was conducted (URS Group, 2002e).
October 2002 to present	Post rebound study sampling suggested that additional mass is available in the vicinity of the 2-Phase® well (TPE-W). A rebound was observed in the ThOx soil vapor samples at the end of the 3-month study (URS Group, 2002d).	Travis AFB is performing a focused extraction on the 2-Phase® extraction (TPE-W) well alone (URS Group, 2002d).

The CGWTP, WTTP, and ThOx system plant are designed to operate unmanned, although monitoring and maintenance is required to ensure proper operation. O&M labor requirements vary from month to month.

5.1.4 Groundwater Treatment

This section presents a summary of treatment system parameters and components and presents a discussion of system performance metrics, discharge standards, and O&M cost and trends.

The groundwater extraction systems at Sites LF008, DP039, and the WIOU are connected to the SS016/ST032 GET system as shown on Figure 5.1-1. Each of these sites is mentioned briefly in this section, although specific details can be found in the following sections:

- Section 6.1 – WIOU
- Sections 6.4 and 6.5 – DP039
- Section 6.6 – LF008

5.1.4.1 Treatment System Parameters and Components

Table 5.1-4 presents a summary of design and actual treatment system parameters for the CGWTP. Parameters for the WTTP are presented in Section 6.1.4. In general, contaminant concentrations in vapor and groundwater are now much lower than were assumed during the design stage.

5.1.4.2 Performance Goals and Metrics

The performance metrics presented and discussed in this section are based on RPO strategies presented in Section 5.0 of the *LTO Strategic Plan* (CH2M HILL, 2001a) and in the RPO Handbook (U.S. Air Force, 1999).

The analyses presented in this section are also presented quarterly in the O&M reports and are designed to address the CGWTP effectiveness in meeting Travis AFB's four main objectives for onbase groundwater treatment facilities. Travis AFB's four main objectives are as follows:

1. Meet IROD cleanup goals
2. Reduce operating costs
3. Reduce time to cleanup
4. Maintain compliance with IROD discharge limits

The first and third objectives, to meet IROD cleanup goals and reduce time to cleanup, at the CGWTP have not yet been operated in a consistently steady manner for any length of time. Since its startup in 1996, the CGWTP has experienced variations in flow rate and mass loading due to the addition of new wells and treatment plant and wellfield modifications. These conditions have also created variations in treatment plant operating costs. The last system modification was the SS016 expansion project in 2001. No additional modifications are planned at this time. The CGWTP is now entering a period of steady-state, long-term operation, allowing for identification of significant trends in performance metrics.

TABLE 5.1-4
CGWTP Design and Actual System Parameters
Groundwater Five-Year Review, Travis Air Force Base, California

Parameter	Design	Actual[a]
Extraction Well Groundwater Flow Rates (gpm)		
EW01x16	30 - 40	18.8
EW02x16	30 - 40	12.7
EW03x16 (DPE)	0.2 - 0.3	0.0
EW605x16 (DPE)	2.0 - 3.0	11.2
EW610x16 (DPE)	2.0 - 3.0	3.9
WTTP	26	29.1
TPE-W	0.3 - 1.0	0.1
Total Flow to CGWTP	102	76
UV/Ox Reactor Flow Rate	150	76
Hydrogen Peroxide Metering Pump (gph)	4	4
2-Phase® Vapor Treatment System		
Extraction Well Vapor Flow Rates (scfm)		
TPE-V	20 - 30	NA
EW605x16 (DPE)	3 - 8	NA
EW610x16 (DPE)	3 - 8	NA
Total Vapor Influent	20 - 35	78.5
Extraction Well Vacuum (in mercury)	15 - 25	NA
Influent Groundwater Contaminant Concentrations (µg/L)		
TCE	1,600[b]	880
Vinyl Chloride	10[b]	1.3
cis-1,2-DCE	600[b]	97
ThOx Influent Soil Vapor Concentrations (parts per billion by volume)		
TCE	390,000	13,000
PCE	NS	160
cis-1,2-DCE	110,000	1,100
1,2-Dichlorobenzene	NS	100
1,4-Dichlorobenzene	NS	64
1,3,5-Trimethylbenzene	NS	48
Carbon Disulfide	NS	240

[a]As of December 2002.
[b]Draft Final *SS016 Remedial Design Report* (Radian, 1998b).
Notes:
gph = gallons per hour
NA = not available
NS = not specified

Meet IROD Cleanup Goals. The IROD IRG for the main COC in the CGWTP system, TCE, is 5.0 µg/L. Progress toward achieving this goal in groundwater can be evaluated through examination of trends in influent VOC concentration and mass removal rate over time.

- **Influent VOC Concentrations –** Influent VOC concentrations at the CGWTP are monitored monthly. Figure 5.1-3 presents the measured influent VOC concentrations over time from July 1999 to August 2002. As shown on Figure 5.1-3, the total influent VOC concentration has fluctuated over time, with an overall decreasing trend. The influent VOC concentration has decreased by approximately 30 percent during this period. The steady decline in influent VOC concentration indicates that the system has been effective in reducing contaminant concentrations in groundwater.
- **Mass Removal Rate –** As shown on Figure 5.1-4, the cumulative VOC mass removed by the CGWTP since startup in 1996 is approximately 2,175 pounds as of August 2002. The rate of VOC mass removal over time is presented on Figure 5.1-5. As shown, the mass removal rate has fluctuated between 0.0 and a high of 6.6 pounds of VOCs per day when the ThOx system was restarted after a rebound period in March 2001. In general, the mass removal rate has continued to increase at the CGWTP as new systems continue to be brought online.

Reduce Time to Cleanup. Reduction in time to cleanup may be achieved through regular review and optimization of system operating parameters.

To achieve reduction in the time to cleanup, extraction rates must be periodically adjusted to provide the greatest mass removal rate possible while maintaining hydraulic capture of plumes. Plant uptime must also be maximized. CGWTP progress, in terms of flow rate and plant uptime optimization, are presented in this section.

- **Optimize Treatment Plant Flow Rate –** The average treatment plant flow rates and target flow rates from February 2000 to the present are presented on Figure 5.1-6. As shown, the total target flow rate for the CGWTP is currently 83 gpm. The actual flow has been generally increasing with time, although it remains below the target flow rate of 90 gpm due to various operational issues.
- **Maximize Treatment Plant Uptime –** The percent uptime goal for all treatment plants at Travis AFB is 100 percent. Although some unexpected shutdowns will occur, with proper planning and maintenance, these occurrences can be minimized. The system uptime is determined by taking into account all factors that cause the plant to shut down. The CGWTP percent uptime is presented on Figure 5.1-7. In general, the percent uptime has remained close to 100 percent, with an average of approximately 94 percent.

Groundwater Discharge Standards. As presented in Section 3.1.4.3 for the NGWTP, all groundwater treatment plants at Travis AFB are required to comply with the substantive requirements of a National Pollutant Discharge Elimination System permit issued by the San Francisco Bay RWQCB. Specific requirements are described in RWQCB Order Number 99-051.

The UV/Ox and LGAC systems have proven effective in removing VOCs from groundwater to below discharge standards and, typically, below analytical detection limits. The majority of contaminant removal takes place in the UV/Ox system. The LGAC vessels provide a polishing step and provide insurance against contaminant breakthrough.

In April 2002, a check-valve failure near the WTTP resulted in the release of approximately 8,000 gallons of untreated water. The check-valve failure was a result of corrosion and normal wear. As a corrective measure to prevent future releases, redundant check valves have been installed.

Vapor Treatment Standards. The ThOx system must provide treatment of the extracted soil vapor stream in accordance with Regulation 8, Rule 47, of the BAAQMD. Based on the vapor concentrations currently observed at the site, this rule requires a minimum of 90 percent reduction of contaminants (by weight). The ThOx system provides sufficient treatment to achieve compliance with this rule.

Cost Evaluation. O&M costs for the CGWTP are tracked monthly and regularly reviewed to evaluate cost effectiveness of the system. Operating costs for the CGWTP reported in this section include the following components:

- Engineering
- O&M
- Performance monitoring (sampling and analysis)
- Reporting
- O&M manual preparation and periodic revision
- Project management and administration
- Utilities

Plant operating costs, operating costs per unit mass contaminants removed, and cumulative operating cost versus cumulative mass removed are presented and discussed in this section.

Operating Costs. A 12-month rolling cost is used to evaluate operating cost due to the high variability of costs from month to month. The 12-month rolling average O&M cost for the CGWTP is $589,000 as of September 2002, and is presented as a function of time on Figure 5.1-8. This cost includes the O&M of the CGWTP and all associated systems, including the WTTP and the ThOx system. As shown on Figure 5.1-8, the O&M cost for the CGWTP has steadily increased over time. Between January 2001 and August 2002, the O&M cost for the CGWTP increased approximately 61 percent. This trend is contrary to the expected trend of decreasing O&M costs with time during LTO/long-term maintenance; however, several factors may explain the increasing costs, including the addition of the WTTP to the CGWTP system in February 2000, and the restart of the ThOx system in March 2001. More than a year has now passed since the last system modification, and O&M costs should level off and begin to decrease. If costs continue to increase, either modification of the treatment train, O&M procedures, or both, may be warranted. No additional modifications are planned for this system.

For comparison, previous forecasts of annual O&M costs for the CGWTP and associated systems are as follows:

- $650,000 per year in the *Remedial Action Strategic Plan* (Radian International, 1998a)
- $1,494,200 in the FS (Radian Corporation, 1996a)

Both of the previous cost estimates are based on assumptions that have since been superceded. For example, the cost estimate in the *Remedial Action Strategic Plan* assumes that there are individual treatment systems at Sites LF008, DP039, SS041/SS043, and in the WIOU. All of the aforementioned sites have since been tied into the WTTP, eliminating the need for onsite treatment systems and, in theory, significantly reducing capital and O&M costs.

The majority of the O&M cost for the CGWTP and associated systems is attributed to operator and engineering labor. Other significant annual fixed costs for the system include the analytical laboratory, hydrogen peroxide for the UV/Ox system, utilities (electricity and natural gas), and carbon changeouts.

12-Month Rolling Cost per Pound. The cost per pound of VOCs removed at the CGWTP and associated systems is $1,520 as of November 2002, and is presented as a function of time on Figure 5.1-9. The cost per pound has been steadily increasing since October 2001. Between February 2001 and November 2002, the cost per pound dropped significantly to a low of $354 per pound in October 2001, then increased steadily to the current value of $1,520. This large dip is attributable to the restart of the ThOx in March 2001, and the subsequent increase in mass removal rate. Concentrations are now beginning to decrease (Figure 5.1-3), and O&M costs continue to increase (Figure 5.1-8); therefore, the cost per pound also continues to increase.

Cumulative Operating Cost versus Cumulative Mass Removed. Another performance metric, which may be used to evaluate the cost effectiveness of the remedy, is the cumulative operating cost versus the cumulative mass removed. A steep rise in this curve would indicate that the cost effectiveness of the system is rapidly decreasing, as would be the case if the operating costs remain constant and the mass removal rate decreases significantly. The cumulative operating cost versus the cumulative mass removed for the CGWTP is presented on Figure 5.1-10. As shown on Figure 5.1-10, a steep upward trend was observed between March 2000 and May 2001, followed by a relatively flat period during the time of high mass removal rate from the ThOx system. Beginning in approximately September 2001, and continuing to date, the trend has again been steeply increasing, indicating that system optimization may be warranted (see Section 5.1.6).

5.1.5 Groundwater Monitoring

The following sections summarize the hydrogeology of Sites SS016 and ST032 and results of groundwater monitoring and modeling conducted in the area of the SS016 GET system and ST032 MNA. A comprehensive description of hydrologic and contaminant data collected at the sites is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2002a). Groundwater modeling performed in support of the five-year review is described in detail in Appendix A.

5.1.5.1 Site Hydrogeology

Site SS016 is bounded on the west by Markley Sandstone (outcrop and suboutcrop). Nortonville Shale underlies the western portion of SS016 and forms the bedrock in that area. This shale was eroded by ancient streams to form a southeast-trending valley in the bedrock surface. To the east, ST032 is underlain by more resistant Domengine Sandstone (Figures 2-1 and 2-2). The area of SS016/ST032 was subsequently overlain by alluvium as described in Section 2.1. Alluvium is composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay. The sand and silty sand were derived from Markley and Domengine Sandstone.

5.1.5.2 Hydraulic Data and Modeling Results

Figure 5.1-11 shows water table elevation contours at SS016 and ST032 during the May 2002 GSAP monitoring event. Figure 5.1-11 also shows the estimated extent of hydraulic capture occurring in 2001, based on calculations performed during the design of the GET system at SS016 (URS Group, 2002h). The extent of hydraulic capture based on the groundwater model is not included on Figure 5.1-11 because of the limited hydraulic data available from this area.

Vertical hydraulic gradients have been evaluated at SS016 using groundwater level measurements in shallow and deep well pairs. No long-term trends in the elevation of the water table have been observed outside the area of the extraction wells.

Hydraulic data and the results of groundwater flow modeling have lead to the conclusions concerning hydrologic conditions in the area of the SS016 GET system and ST032 MNA presented in Table 5.1-5.

TABLE 5.1-5
Conclusions Concerning Hydrologic Conditions in the Area of the SS016 GET System and ST032 MNA
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is approximately 8 to 12 feet bgs outside the area of SS016 extraction wells. In the vicinity of groundwater extraction wells, the water table is up to 16 feet bgs.
2.	Regional groundwater flow is south to southeasterly at SS016/ST032.
3.	Groundwater from the OSA, area of the Base Control Tower, and Site ST032 converge in the southern portion of SS016/ST032 (Figure 5.1-11) and continue to the south-southeast toward SS029 and FT005.
4.	Directions and rates of groundwater flow vary across SS016/ST032, largely due to pumping at SS016 groundwater extraction wells. Lateral hydraulic gradients vary from approximately 0.003 foot/foot outside the area of extraction wells to ≥ 0.01 foot/foot near extraction wells.
5.	Based on the results of groundwater elevation monitoring, groundwater contamination above 1,000 µg/L is largely captured by groundwater extraction wells at SS016. However, TCE was detected at 1,010 µg/L in MW606x16 during the May 2002 monitoring event approximately 150 feet south of extraction well EW605x16.
6.	If contaminated groundwater from the area of SS016/ST032 migrates south, it should be captured by SS029 or FT005 GET systems.
7.	Vertical hydraulic gradients vary at SS016/ST032. Of the four shallow and deep well pairs at SS016, none showed significant vertical gradients (greater than ± 0.05 foot/foot) during the 2001-2002 GSAP.
8.	The extent of hydraulic capture in the OSA area is hampered by the design of the GET system. Extraction wells installed along the flow path, rather than across the flow path, reduce the extent of capture.

5.1.5.3 Groundwater Quality Data

Figure 5.1-12 shows TCE concentrations detected in the May 2002 GSAP event at Sites SS016 and ST032. Figures 5.1-13 and 5.1-14 present time series plots of TCE and benzene at selected monitoring and extraction wells.

The objective of groundwater monitoring at SS016 and ST032 is to confirm both Source Control and Migration Control. The SS016 Source Control objective stated in the IROD is to capture TCE at concentrations greater than 3,000 µg/L; however, the extraction system was designed to capture TCE at concentrations greater than 1,000 µg/L. The Migration Control objective for Sites SS016 and ST032 is to prevent groundwater contamination at the southern edge of the plume from discharging into Union Creek. Groundwater quality data collected from the monitoring network at SS016/ST032 support the conclusions summarized in Table 5.1-6.

TABLE 5.1-6
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

Groundwater Quality Conclusions
1. 2001-2002 GSAP groundwater quality data collected from Sites SS016/ST032 indicate that the Source Control objective is being achieved at all of the main source areas at SS016, with one exception (Figure 5.1-12). One monitoring well located approximately 75 feet downgradient of the OSA extraction system (MW606x16) had a TCE detection of 1,010 µg/L during the May 2002 sampling event. However, TCE concentrations in this well varied between 770 and 1,010 µg/L during the 2001-2002 GSAP. The monitoring history at this well is too short to assess trends (Figure 5.1-13). TCE concentrations in the deeper well in this pair (MW609x16) remain below 1,000 µg/L. TCE concentrations at monitoring well MW611x16, located approximately 160 feet northeast of MW606x16, are decreasing (Figure 5.1-13).
2. Although COC concentrations remain high in OSA extraction well EW03x16, over time, COC concentrations have significantly declined in the monitoring wells near EW03x16, such as MW214x16 and MW212x16 (Figure 5.1-14). TCE concentrations are below 1,000 µg/L in all but three monitoring wells in the OSA source area.
3. Except for the OSA source area, TCE was not detected above 1,000 µg/L in any extraction well or monitoring well (Figure 5.1-13). Concentrations of COCs were stable or declining in all other source areas at SS016 during the 2001-2002 GSAP (Figure 5.1-13).
4. In the southernmost portion of SS016, COC concentrations remain above IRGs. Long-term contaminant concentration trends appear to be downward (illustrated by monitoring wells MW244x16, MW245x16, MW109x16, MW611x16, and MW1022x16 on Figure 5.1-13). However, trends of increasing TCE concentrations at upgradient SS029 monitoring wells indicate that the plume is migrating south of the runway to Site SS029.
5. A monitoring well pair in the OSA source area (MW214x16/MW305x16) shows that the groundwater contamination in the source area is limited to the saturated sediments above the bedrock. Concentrations of TCE (3,100 µg/L), cis-1,2-DCE (840 µg/L), and PCE (16 µg/L) detected during the 2001-2002 GSAP were elevated in the shallow well (MW214x16). However, no COCs were detected in deep well MW305x16, which is screened in bedrock.
6. The fairly uniform spread of contamination throughout the saturated sediments in the downgradient portion of the plume is demonstrated by monitoring well pair MW245x16/MW316x16. The maximum concentration of TCE detected in the deep well MW316x16 during the 2001-2002 GSAP was 78 µg/L. The maximum concentration detected in the shallow well MW245x16 during the same time period was 51 µg/L.
7. Although newly installed extraction wells EW610x16 and EW605x16 are useful in mitigating groundwater contamination in the central portion of SS016, they will not control migration in the southern portion of SS016. TCE concentrations beyond the influence of these extraction wells currently exceed 100 µg/L.
8. Contamination escaping the extraction system at SS016 appears to be captured by the extraction system at SS029 (see Section 4.1). As discussed in Section 4.1, Union Creek water quality does not appear to be adversely affected by groundwater contamination in the SS016/ST032 or SS029 areas.
9. TCE continued to be observed at concentrations above the IRG at Outfall 3 in Union Creek in 2001-2002. However, TCE concentrations are declining over time at Outfall 3, and the SS016 groundwater extraction system might be responsible for this decline by lowering the water table and reducing the role of the storm sewer as a conduit for groundwater flow.
10. ST032 serves as the eastern boundary to the chlorinated hydrocarbon contamination observed at SS016. Chlorinated hydrocarbons are not an issue at this site.
11. Elevated benzene and TPH-G concentrations continue to be observed in monitoring wells at Site ST032. These include both the Plume A area (MW1028x32) and the Plume B area (MW246x32). However, benzene and TPH-G concentrations have been generally declining over time, and are not observed at elevated concentrations at other nearby monitoring wells (Figure 5.1-14). Benzene concentrations at MW1028x32 appear to have rebounded somewhat in the May 2002 sampling event; however, benzene concentrations remain below the historical maximum. The contamination is stable, restricted, and declining at ST032.
12. Operation of a passive hydroskimmer addressed the floating product historically observed at ST032. Measurable amounts of floating product were not observed at ST032 during the 2001-2002 GSAP.

Insufficient hydraulic data (both head and hydraulic conductivity) were available to perform detailed site modeling at SS016. At best, cleanup estimates based on modeling are estimates. The empirical groundwater quality data collected at SS016 to date indicate that the extraction systems appear to be capturing TCE above 1,000 μg/L. VOC concentrations below that level are migrating south, but should be captured by the extraction system at SS029. Long-term monitoring will track these issues.

Groundwater modeling performed during the FS estimated that it would take 193 years for TCE concentrations to reach 5 μg/L at SS016 (Radian Corporation, 1996). Based on concentrations currently observed at this site, it seems reasonable that cleanup will require more than a century.

5.1.6 Opportunities for Optimization

Source Control appears to have been achieved at SS016. However, opportunities for optimization, either in terms of reduction in time to cleanup or reduction in O&M cost, for the CGWTP system, are identified in this section. The following potential areas for optimization are evaluated:

- Extraction well flow adjustments to increase mass removal rate and decrease O&M cost while maintaining IROD objectives
- Modification of ex situ treatment systems to reduce O&M cost
- Implementation of in situ technologies to reduce time to cleanup

Each potential area for optimization is discussed briefly in the following sections. Table 5.1-7 summaries the opportunities for optimization discussed below.

TABLE 5.1-7
Recommendations for Optimization of the CGWTP and Related Systems
Groundwater Five-Year Review, Travis Air Force Base, California

Recommendations for Optimization
1. Evaluate replacement of the ThOx system with VGAC – possibly using the existing vessels at the WTTP (see Section 6.4.6).
2. Evaluate replacement of UV/Ox and LGAC vessels at CGWTP with a low-profile air stripper.
3. Consider in situ technologies to reduce source area contaminant mass.

5.1.6.1 Extraction Well Flow Adjustment

None of the SS016/ST032 wells are good candidates for flow reduction at this time. The TCE concentration in all six extraction wells is greater than 100 μg/L, and the concentration is greater than 1,000 μg/L in four of the six. The objective of the extraction system at SS016/ST032 is to capture groundwater with TCE concentration greater than 1,000 μg/L. The two wells with concentrations less than 1,000 μg/L are located on the downgradient side of the plume nearest to the runway. Continued pumping of these wells will prevent further migration of contaminants under the runway and increase the mass removal rate for the area.

5.1.6.2 Installation of New Extraction Wells

Given the difficulties associated with working on the flightline, no additional wells are recommended in this area for increasing the rate of source area mass removal. The existing extraction system continues to provide hydraulic control and mass removal from this area.

5.1.6.3 Modification of Ex Situ Treatment System

Several process modifications to the CGWTP and associated systems have the potential to reduce operating costs, including replacement of the ThOx system with VGAC and consideration of air stripping at the CGWTP in place of the UV/Ox and carbon system.

When the SVE system was first installed in the SS016 area, vapor concentrations were high enough to warrant treatment with ThOx. Because concentrations have decreased significantly, treatment technologies with lower O&M costs, such as granular-activated carbon , may be considered. All compounds currently found in the ThOx influent stream would be effectively treated with granular-activated carbon , with the exception of carbon disulfide. At current concentrations (0.240 parts per million by volume), carbon disulfide would pass through a granular-activated carbon treatment system untreated and result in atmospheric emissions at a rate of 0.006 pound per day, or 2.1 pounds per year. This emission rate is likely low enough that control would not be required by the BAAQMD; however, additional evaluation, including the preparation of a risk assessment and discussion with regulatory agencies, would be initiated prior to implementation of any equipment changes.

The conversion to granular-activated carbon could result in substantial O&M cost savings and should be considered, particularly if carbon disulfide concentrations continue to decline. It may be possible to use the existing VGAC system currently located at the WTTP for SS016, as long as it could be demonstrated that vapor treatment is no longer needed at the WTTP. The two 2,000-gallon vessels could be moved from the WTTP to SS016 and used to replace the ThOx system at no capital cost. Vendor modeling, based on December 2002 concentrations at the ThOx inlet, predicts that the VGAC vessels could be expected to accommodate the SS016 vapor flow for approximately 220 days before breakthrough of the first vessel. All compounds would be effectively removed, with the exception of carbon disulfide, which would not be treated. O&M costs for the VGAC system are likely to be substantially less than that for the ThOx system, although a cost benefit evaluation is recommended to quantify the potential savings.

It may also be possible to replace the existing groundwater treatment units at the CGWTP with a simpler and more cost-effective system. A cost-benefit evaluation should be performed to determine the best technology for LTO/long-term maintenance at the CGWTP given the current flow rate and contaminant concentrations. The existing system is much larger and more complex than is required to treat the current stream. The 20,000-pound carbon vessels are significantly oversized for the current flow rate at the CGWTP (76 gpm). For optimal adsorption, carbon vessels should operate with a hydraulic loading between 2 and 8 gpm per square foot, with a typical value of 5 gpm per square foot. The current hydraulic loading through the CGWTP vessels is 0.97 gpm per square foot. In this case, where the hydraulic loading is outside the recommended range on the low side, the consequence may be inefficient adsorption and higher carbon consumption rates due to preferential flow pathways through the media. However, prior to making any equipment changes, a complete cost-benefit evaluation should be performed.

If it were not for the vinyl chloride in the influent stream, granular-activated carbon could be a cost-effective option for this site. However, as long as vinyl chloride concentrations (1.3 µg/L in December 2002) remain above the discharge limit (0.5 µg/L), granular-activated carbon cannot be used because it would not provide sufficient treatment. Alternatively, air stripping, like the systems used at the NGWTP and SBBGWTP, could be used to treat all compounds currently found in the influent stream and could be a cost-effective alternative to the current system over the life of the project. Standardization of technologies among the three treatment plants might also yield some savings as equipment, materials, and operator knowledge could be shared among the plants.

A detailed cost-benefit analysis would be required to quantify the potential savings in long-term O&M costs with simplification of the CGWTP system under either of the above alternatives.

5.1.6.4 Implementation of In Situ Technologies

In situ technologies could decrease the time to cleanup, if implemented in the SS016/ST032 area. Due to the proximity of this area to the flightline, some of the more aggressive technologies for source area mass removal, such as chemical oxidation or surfactant flushing, are not appropriate because the implementation would be too disruptive to the Base mission. One of the least disruptive and lowest cost alternatives is enhanced bio-remediation. As previously described in Section 4.1.6, bioremediation does have the potential to significantly decrease contaminant mass in place at the site and, thus, reduce the time the cleanup. Enhanced bioremediation can comprise a number of strategies, but generally consists of the injection of an electron donor into the subsurface to stimulate biological reductive dechlorination. This technology is potentially effective for the majority of chlorinated solvents at SS016/ST032.

5.1.7 Technical Assessment

5.1.7.1 Is the Remedy Functioning as Intended by the IROD?

Yes. Source Control appears to have been achieved. Migration Control is limited due to conflict with the Base mission along the runway. Instead, migrating contamination will be mitigated by the SS029 or FT005 GET system south of the runway. The plume has not been fully characterized at the downgradient end, due to the presence of the runway. Indications are that the SS016 plume has now reached the northern edge of SS029, based on recent GSAP data. However, this should not impact the protectiveness of the remedy, because the existing GET system in this area should capture the contamination. Ongoing monitoring will be needed to ensure that the capture is achieved on an ongoing basis.

5.1.7.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are no exposure pathways to human receptors. TCE concentrations in surface water discharge at Outfall 3 are low and declining over time, and groundwater discharges to Union Creek do not show elevated VOC concentrations to date. These discharges do not represent a significant threat to ecological receptors.

5.1.7.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. The remedy at these sites appears to be protective, especially considering the down-gradient extraction systems at FT005 and SS029. There are no anticipated changes to the current land usage, and risks are being adequately managed at these sites. In addition, the sites are not subject to natural disasters that may affect protectiveness.

5.1.8 Statement of Protectiveness

The GET remedy at Site SS016 is expected to be or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

5.1.9 References

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Figure
5.1-1 SS016/ST032 Site Map
11 x 17 color

Figure 5.1-1 continued

Figure
5.1-2 CGWTP Process Flow Diagram
11 x 17 b&w page 1 of 2

Figure 5.1-2 back

Figure 5.1-2 page 2 of 2

Figure 5.1-2 page 2 of 2 back

Figure
5.1-3 CGWTP Influent Concentration over Time
8.5 x 11 b&w

Figure
5.1-4 CGWTP Cumulative VOC Mass Removed over Time
8.5 x 11 b&w

Figure
5.1-5 CGWTP VOC Mass Removal Rate over Time
8.5 x 11 b&w

Figure
5.1-6 CGWTP Groundwater Flow Rate over Time
8.5 x 11 b&w

Figure
5.1-7 CGWTP Percent Uptime over Time
8.5 x 11 b&w

Figure
5.1-8 CGWTP Rolling 12-month Operating Costs
8.5 x 11 b&w

Figure
5.1-9 CGWTP Rolling 12-month Cost per Pound of VOCs Removed
8.5 x 11 b&w

Figure
5.1-10 CGWTP Cumulative Operating Costs versus Cumulative Mass Removed
March 2000 - November 2002
8.5 x 11 b&w

Figure
5.1-11 Groundwater Elevations Measured at SS016/ST032 during May 2002
11 x 17 color

Figure 5.1-11 continued

Figure
5.1-12 TCE Distribution at SS016, ST032
11 x 17 color

Figure 5.1-12 continued

Figure
5.1-13 TCE Chemical Time Series Plots for SS016/ST032
8.5 x 11 b&w (page 1 of 2)

Figure 5.1-13 page 2 of 2

Figure
5.1-14 Benzene Chemical Time Series Plots for SS016/ST032
8.5 x 11 b&w

SECTION 6.0

West IRA Area

6.1 WIOU Groundwater Extraction and Treatment System

6.1.1 Site Description

The WIOU GET system includes several sites that were combined because of their geographical proximity and the similarity of contamination. A large plume of chlorinated VOCs underlies much of this area, and has resulted from many individual sources at these contiguous sites. Sites included in the WIOU GET system include WIOU sites (SS014, SD033, SD034, SS035, SD036, and SD037) and WABOU sites (SS041 and SD043). Extraction wells are located at each of these sites, except for SS014 and SS035. The features of the northern WIOU (and Eastern WABOU), where the GET action is occurring, and locations of monitoring wells are shown on Figure 6.1-1 (CH2M HILL, 2002a).

The sites addressed by the WIOU GET system are located within industrialized areas of the WIOU and WABOU, near the west-central portion of Travis AFB. The West Branch of Union Creek traverses between the WIOU and the WABOU and flows generally north to south, with the slope of the topography. Facilities within the WIOU include numerous buildings, shops, offices, freight handling/storage areas, vehicle maintenance shops, and aircraft maintenance facilities. Activities at the two WABOU sites include pesticide mixing and handling and electrical power generation.

Table 6.1-1 provides a summary of the WIOU GET sites, as well as a brief site description and listing of COCs. The indicator chemical for all of the wells sampled for the WIOU GET is TCE.

6.1.2 Site History and Status

The primary objectives of the WIOU GET, as specified in the *WIOU Interim Groundwater Remedial Design/Remedial Action* (CH2M HILL, 1999d), are Source Control and Migration Control. Source Control actions address areas of groundwater contamination where VOC concentrations are 1,000 µg/L and greater. The objectives of the Source Control actions in these areas are hydraulic containment and mass removal, to the extent that it is technically and economically feasible. Migration Control actions address areas of groundwater contamination where VOC concentrations are between 100 µg/L and 1,000 µg/L. The primary objective of the Migration Control action in these areas is hydraulic containment, to the extent that it is technically and economically feasible.

Migration Control in areas with VOC concentrations less than 1,000 µg/L is not a strict requirement of the *Groundwater IROD for the NEWIOU.* However, the Air Force is conducting this action because achieving hydraulic containment of the 100-µg/L target areas is cost effective and has other long-term benefits. This action will prevent the medium-concentration contaminants (i.e., concentrations between 100 µg/L and 1,000 µg/L) from migrating into lesser-contaminated areas of the aquifer where MNA is undergoing evaluation.

As mentioned above, the WIOU GET system includes two WABOU sites (SS041 and SD043). These sites are addressed in this section. Two other WABOU sites also pump water to the WTTP, where it is mixed with water from the WIOU GET sites. These sites (DP039 and LF008) are addressed in Sections 6.4 and 6.5.

A separate MNA assessment is occurring in the southern portion of the WIOU, down-gradient from the 100-µg/L TCE isoconcentration line. The MNA assessment primarily affects two sites: SD033 and SD037. The WIOU MNA action is addressed in Section 6.2.

Two sites within the WIOU GET area additionally have ongoing floating-product removal actions underway. Both active and passive skimming is used to address Stoddard solvent contamination at Site SD034. Passive skimming is used to address fuel contamination at Site SS014. Groundwater in the vicinity of these sites is also contaminated with chlorinated VOCs.

One additional site (SS035) was designated for MNA assessment in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). However, since other sites are undergoing GET surround this site, stakeholders realized that MNA is not logical at this site. Therefore, contamination at SS035 is addressed through GET with an objective of Migration Control.

The WTTP was brought online in February 2000, and is designed to pump water to the CGWTP for treatment from 24 extraction wells in the WIOU (from Sites SD033, SD034, SD036, and SD037) and the WABOU (from Sites DP039, SD041, SD043, and LF008) (URS Group, 2002f).

6.1.3 Interim Remedial Action

6.1.3.1 Interim Remedial Action Objectives

The primary objectives of the WIOU GET, as specified in the *WIOU Interim Groundwater Remedial Design/Remedial Action* (CH2M HILL, 1999d), are Source Control and Migration Control. Source Control actions address areas of groundwater contamination where VOC concentrations are 1,000 µg/L and greater. The objectives of the Source Control actions in these areas are hydraulic containment and mass removal, to the extent that it is technically and economically feasible. Migration Control actions will address areas of groundwater contamination where VOC concentrations are between 100 µg/L and 1,000 µg/L. The primary objective of the Migration Control action in these areas is hydraulic containment, to the extent that it is technically and economically feasible.

The actions and objectives in Table 6.1-2 were selected for the WIOU GET sites in the IRODs (Travis AFB, 1997; Travis AFB, 1999).

6.1.3.2 Remedy Description

Contaminated groundwater and soil vapor collected at the WIOU and WABOU are transported to the WTTP. Contaminated soil vapor is treated at the WTTP using a VGAC system. However, the extracted groundwater is transferred for treatment to the CGWTP, along with

TABLE 6.1-1
Summary of WIOU GET Sites
Groundwater Five-Year Review, Travis Air Force Base, California

Site	Site Description	Site COCs	Interim Remedial Action
SD033	Composed of four noncontiguous areas: 1) Storm Sewer System 2 (SSS 2 – major surface water drainage network within the WIOU; includes West Branch of Union Creek and a underground pipe system.) 2) Facility 810 (Constructed in 1955, used for aircraft refurbishing activities. An OWS, sump, and washrack previously existed at the site and discharged to SSS 2. The equipment has been abandoned; facility no longer discharges to SSS 2.) 3) Facility 1917 (Constructed in 1956 and used as an aircraft washdown area. OWS and wastewater collection sumps remain at the facility but are no longer in use.) 4) South Gate Area (Undeveloped area near crossroads of Ragsdale Street and Perimeter Road. Included as part of SD033 because groundwater contamination detected at the site was thought to come from SSS 2. It was later discovered that SSS 2 does not flow into this area.)	TCE 1,1-DCE 1,2-DCA cis-1,2-DCE TPH-G TPH-D	Groundwater contamination of Facility 810 addressed by WIOU GET. Goal is Migration Control. The South Gate Area and Facility 1917 were addressed by the *WIOU Natural Attenuation Assessment Work Plan* (CH2M HILL, 2001e), which concluded no further action was required to address these areas. Facility 810 was originally intended for MNA; however, is within the capture zone of the WIOU GET. The downgradient portion of the dissolved plume, including SSS 2, is addressed by MNA (CH2M HILL, 2001e).
SD034	Composed of Facility 811, an indoor aircraft washrack: The primary operation conducted at Facility 811 is aircraft cleansing using a mixture of PD-680 (Stoddard solvent) and aircraft soap. Each month, 4 to 6 gallons of paint stripper may also be used. Wastewater from the washrack flows through an OWS to publicly owned treatment works or to a concrete-lined overflow pond west of the facility. A hole was found in the OWS in 1994, and the OWS was removed and replaced. An aboveground storage tank containing Stoddard solvent is located on the northern side of the facility.	TCE PCE 1,1-DCE cis-1,2-DCE benzene vinyl chloride TPH-G TPH-D bis(2-ethylhexyl)phthalate PD-680 Stoddard solvent	Site groundwater is addressed by WIOU GET. The goal is Migration Control. In addition, a floating-product (Stoddard solvent) removal action is also being performed at the site.
SS035	Facilities 818 (constructed 1970) and 819 (constructed 1974): Facility 818 used to repair, wash, and paint aircraft. Wastewater from facility flows into trench connected to OWS that discharges to the sanitary sewer system. Facility 819 contains a hydraulic shop, electro-environmental shop, a wheel and tire shop, and a hazardous materials accumulation area. Chemicals used at SS035 include lubricating oil, hydraulic fluid, and solvents (including Stoddard solvent).	TCE TPH-D	In the *Groundwater IROD for the NEWIOU*, MNA was selected for this site; however, due to the proximity of the site to the WIOU GET, groundwater extraction is a more practical solution. Goal is Migration Control.

TABLE 6.1-1
Summary of WIOU GET Sites
Groundwater Five-Year Review, Travis Air Force Base, California

Site	Site Description	Site COCs	Interim Remedial Action
SD036	Composed of three facilities built in 1953: 872, 873, 876 Facility 872 was used for maintenance and storage of civil engineering vehicles and landscaping equipment. An OWS was removed from the facility in 1994. Currently, the facility is used as an office for civil engineering personnel. Facility 873 contains the civil engineering interior electric, locksmith, and paint shop. A fenced area south of the facility is used to maintain electric motors and store scaffolding. Facility 876 is used for paint mixing. An accumulation area for waste paints and thinners generated at Facility 874 is adjacent to the area. Chemicals used at these facilities include cleaning solutions, grease, degreasers, hydraulic oils and fluids, Soddard solvent, pesticide paints, and solvents.	TCE PCE 1,1-DCE 1,2-DCA cis-1,2-DCE benzene Vinyl chloride Bromodichloromethane TPH-G TPH-D	Site is addressed by WIOU GET. Goal is Source Control and Migration Control. Both groundwater and soil vapor are extracted and treated.
SD037	A large 90-acre site within an industrialized area of the WIOU. Numerous buildings, shops, offices, freight handling/storage, and aircraft maintenance facilities are within site boundaries. SD037 includes Facilities 977, 981, 919, the Area G ramp, and the Ragsdale/V Area. A portion of Travis AFB Sanitary Sewer System underlies the site (22,000 feet of underground piping). Portions of SSS 2 and the jet-fuel distribution system also underlie the site.	TCE PCE 1,1-DCE 1,2-DCA Benzene Bromodichloromethane cis-1,2-DCE Carbon tetrachloride Chloromethane Vinyl chloride TPH-G TPH-D Bis(2-ethylhexyl)phthalate	WIOU GET addresses northern portion of site. Goal is Source Control and Migration Control. MNA has been selected for portions of the plume near Facility 977 and the Area G Ramp.
SS041	Facility 905 (entomology shop) was used to prepare pesticides and herbicides from 1983 to 1992. Fenced enclosure outside contains a washrack and storage area. Washrack formerly used to wash tractors that towed bowsers filled with pesticides and herbicides.	Heptachlor epoxide	WIOU GET addresses site. Goal is Migration Control.
SD043	Facility 916 was constructed in 1953 to provide emergency electrical power. Cellar contains diesel-powered generators and sump pumps. Prior to 1991, diesel spilled from generators was washed down with water and pumped out of the building, discharged to concrete spillways leading to a drainage channel. TCE has historically been detected at relatively low concentrations in groundwater near SD043. The source of the TCE is uncertain.	TCE	WIOU GET addresses site. Goal is Migration Control.

contaminated groundwater from Sites SS016, LF008, and DP039. The CGWTP is located to the east of the WIOU, at Site SS016. The process flows for the WTTP and CGWTP are shown on Figure 5.1-2.

The use of eductor pumps rather than submersible pumps is an innovative groundwater extraction method at the WIOU. The WIOU employed eductors at each extraction well that contains no motors or moving parts. The application of eductor technology has reduced O&M costs for this wellfield. Submersible pumps typically require a great deal of maintenance, particularly in settings like Travis AFB where low well yields cause the pumps to frequently cycle on and off.

TABLE 6.1-2
Selected Interim Actions at WIOU Sites
Groundwater Five-Year Review, Travis Air Force Base, California

Site	Monitored Natural Attenuation	Groundwater Extraction and Treatment	
		Source Control	Migration Control
SS014[a]	X[b]	X[c]	
SD033	X		X
SD034		X[d]	X
SS035	X[e]		
SD036[f]	X	X	X
SD037	X	X	

[a] SS014 is a POCO site and is not included in the IROD. It is included here because it is contiguous.
[b] MNA affects Subsites 1 and 4.
[c] Source Control consists of passive skimming of free-product jet-fuel product at Subsite 1.
[d] Source Control by active and passive skimming of free product Stoddard solvent.
[e] Originally designated for MNA in the *Groundwater IROD for the NEWIOU*, but later reverted to GET because it is within the capture zone of surrounding extraction wells.
[f] Originally the object of an MNA treatability study, later selected for Source Control and Migration Control via GET.

6.1.3.3 Implementation

The WTTP was brought online on 01 February 2000, and is designed to pump water to the CGWTP for treatment from 24 extraction wells in the WIOU (from Sites SD033, SD034, SD036, and SD037) and the WABOU (from Sites DP039, SD041, SD043, and LF008). The WTTP contributes about 40 to 45 gpm to the total CGWTP flow (URS Group, 2002f). See Section 5.1.3.2 for a complete background on the implementation of CGWTP and all of its components.

6.1.3.4 Operations

Operations issues for the CGWTP and WTTP are addressed in Table 5.1-3.

6.1.4 Groundwater Treatment

Extracted soil vapor from the WIOU is treated and discharged at the WTTP. Extracted groundwater is collected in a transfer tank located at the WTTP, and then conveyed to the CGWTP for treatment and discharge. Treatment and transfer systems at the WTTP are described further in the following subsections.

6.1.4.1 Treatment System Parameters and Components

Table 6.1-3 presents a summary of design and actual treatment system parameters for the WTTP. Groundwater and soil vapor flow rates at the WTTP are generally within design ranges. Contaminant concentrations in both groundwater and soil vapor have decreased significantly since the design phase.

TABLE 6.1-3
WTTP Design and Actual System Parameters
Groundwater Five-Year Review, Travis Air Force Base, California

Parameter	Design	Actual[a]
System Groundwater Flow Rates (gpm)		
Eductor Supply	82	NA
Eductor Discharge	108	NA
Net Extracted Flow Rate	26	29.1
Extracted Vapor Flow Rate (scfm)	250 - 700	370
Composite Soil Vapor Concentrations[b] (parts per billion by volume)		
TCE	2,100	12
cis-1,2-DCE	600	ND
Acetone	NS	90
Composite Groundwater Contaminant Concentrations[b] (µg/L)		
TCE	1,191	350
cis-1,2-DCE	168	15

[a]As of December 2002.
[b]List does not include all detected compounds, only primary COCs for treatment.
Notes:
NA = not available
NS = not specified

The performance of the WTTP is discussed as part of the CGWTP performance evaluation in Section 5.1.4.2. One performance measure specific to the WTTP is the VOC concentration of extracted groundwater over time (see Figure 6.1-2). As shown on Figure 6.1-2, both the extracted soil vapor and groundwater concentrations have continued to decrease over time. The total VOC concentration has decreased 11 percent in groundwater and 77 percent in soil vapor between startup in February 2000 and December 2002.

6.1.4.2 Discharge Standards

Vapor emissions from all SVE and air stripping operations at Travis AFB, including the WTTP, must comply with Regulation 8, Rule 47, of the BAAQMD. As discussed in the *CGWTP Quarterly Report* (URS Group, 2002e), air emissions from the WTTP are exempt from this rule and, based on a risk assessment presented in the *CGWTP Quarterly Report* (URS Group, 2002e), would pose an insignificant risk to nearby receptors. On this basis, discontinuation of vapor treatment at the WTTP may be possible. Monitoring would be continued to ensure mass loading rates remain below threshold levels.

6.1.4.3 Cost Evaluation

Costs for the O&M of the WTTP are included in the costs for the CGWTP system as presented in Section 5.1.4.4. Costs are tracked and evaluated only for the CGWTP system as a whole.

6.1.5 Groundwater Monitoring

The following sections summarize the hydrogeology of the WIOU and results of groundwater monitoring and modeling conducted in the area of the WIOU GET system (Sites SD033, SD034, SS035, SD036, SD037, SS041, and SD043). A comprehensive description of hydrologic and contaminant data collected in the WIOU is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2002a). Groundwater modeling performed in support of the five-year review is described in detail in Appendix A.

6.1.5.1 Site Geology

The WIOU is bounded on the east by Markley Sandstone (outcrop and suboutcrop). To the west, the sites are bounded by outcrop of the Tehama Formation (low hills in the area of the WABOU). Neroly Sandstone underlying the WIOU was eroded by ancient streams to form a south-southeast trending valley in the bedrock surface (Figures 2-1 and 2-2). The area was subsequently overlain by alluvium as described in Section 2.1. Alluvium ranges from 20 to 60 feet thick in the WIOU (based on drilling). The thickness of alluvium generally increases to the southeast. Alluvium is composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay. Sand and silty sand were derived from nearby Markley Sandstone.

The West Branch of Union Creek runs north to south between the WIOU and WABOU (Figure A-3 in Appendix A).

6.1.5.2 Hydraulic Data and Modeling Results

On a seasonal basis, the elevation of the water table typically varies 2 to 5 feet. However, no long-term trends in the elevation of the water table have been observed outside the area of the extraction wells.

Figure 6.1-3 shows water table elevation contours in the WIOU during the May 2002 GSAP monitoring event. This figure also shows the extent of hydraulic capture anticipated in the vicinity of WIOU extraction wells (based on modeling performed during the design of extraction well fields) and the estimated extent of hydraulic capture occurring in 2001 (based on modeling performed during the five-year review). Vertical hydraulic gradients have been evaluated in the WIOU using groundwater level measurements in shallow and deep well pairs.

Table 6.1-4 presents the conclusions concerning hydrologic conditions in the WIOU derived from hydraulic data and the results of groundwater flow modeling.

6.1.5.3 Groundwater Quality Data

Figure 6.1-4 shows TCE concentrations detected in the May 2002 GSAP event in the WIOU GET area. Figure 6.1-5 presents time series plots of TCE concentrations over time in selected WIOU extraction wells and monitoring wells.

TABLE 6.1-4
Conclusions Concerning Hydrologic Conditions in the WIOU
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is approximately 8 to 14 feet bgs outside the area of WIOU extraction wells. In the vicinity of groundwater extraction wells, the water table is up to 25 feet bgs.
2.	Regional groundwater flow is southerly.
3.	Directions and rates of groundwater flow vary across the WIOU, largely due to pumping at groundwater extraction wells. Lateral hydraulic gradients vary from approximately 0.003 foot/foot outside the area of extraction wells to ≥ 0.1 foot/foot near extraction wells.
4.	The existence of inward gradients (converging flow) in the vicinity of extraction wells EW501x33, EW03x34, EW593x36, EW594x36, EW701x37, EW703x37, EW704x37, EW07SCAPSx37, EW510x37, EW511x37, and EW707x37 is well established by GSAP groundwater level measurements. Flow modeling conducted as part of the five-year review indicates that the zone of hydraulic capture created by pumping at WIOU extraction wells likely extends 600 feet east of MW538x37, EW599x37, and MWSNSM4x37; south to MW505x33 and MW518x37; west to the area of Dixon Avenue in the southern portion of the WIOU and to MW1205x37 in the northern portion of the WIOU; and approximately 100 feet north of MWSNSM4x37 as shown on Figure 6.1-3.
5.	Based on the results of groundwater level monitoring and flow modeling, groundwater contamination above 100 µg/L is being captured by groundwater extraction wells in the WIOU (i.e., GET systems are achieving the design objective).
6.	Vertical hydraulic gradients vary in the WIOU. Of the nine shallow and deep well (and piezometer) pairs in the WIOU, two showed significant vertical gradients (greater than ± 0.05 foot/foot) during the 2001-2002 GSAP: well pair MW512x37 and MW535x37 (downward) and piezometer pair PZ11Sx36 and PZ11Dx36 (downward). Significant vertical gradients at these locations are likely due to pumping at nearby extraction wells.

The main objective of groundwater monitoring at the WIOU GET is to verify that the Source Control and Migration Control objectives are being achieved. In the WIOU, Source Control actions address areas of groundwater contamination where VOC concentrations are 1,000 µg/L or greater. Migration Control actions address areas of groundwater contamination where VOC concentrations are between 100 µg/L and 1,000 µg/L. Groundwater quality data collected from the monitoring network in the WIOU GET area support the conclusions summarized in Table 6.1-5.

The WABOU RI originally concluded that PCB-1254 was a COC in groundwater at Site SD043. However, subsequent investigations concluded that PCB-1254 should be a COC in soil, but not groundwater, at SD043. This decision was documented in a technical memorandum and later referenced in the *Soil ROD for the WABOU* (CH2M HILL 2000c; U.S. Air Force, 2002).

6.1.5.4 Time to Cleanup

Simulations of contaminant migration and estimates of the time to clean contaminated groundwater are approximate. These simulations reflect available information describing the distribution of groundwater contaminants (and sources) and rates and directions of groundwater flow through the aquifer (present and future). In addition, they reflect the inherent limitations of technologies available to simulate contaminant transport in aquifers. In addition, the estimates do not take into account the effect that natural attenuation may have on TCE concentrations. Consequently, estimates of cleanup time are mainly of qualitative or comparative value and should not be taken as exact times to clean contaminated groundwater. Despite these limitations, cleanup times for TCE-contaminated groundwater in the area of the WIOU have been estimated to facilitate the evaluation of existing WIOU GET systems.

TABLE 6.1-5
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	Capture zone analysis through groundwater modeling has been performed for the WIOU GET. Results of the analysis, as shown on Figure 6.1-4, indicate monitoring wells with TCE concentrations exceeding 100 µg/L are within the WIOU GET hydraulic capture zone.
2.	The 100-µg/L line is poorly defined in the vicinity of Ragsdale Street and southern Site SD036. Two existing piezometers (PZ20x36 and PZ22x36) will be added to the GSAP for sampling to better define the 100-µg/L line in this area.
3.	With the possible exception of one monitoring well, MW518x37, located within, but near, the edge of the modeled extent of hydraulic capture, concentrations in WIOU GET wells do not indicate continued plume migration. Increasing TCE concentrations in MW518x37 probably signify contamination that is migrating to nearby extraction well EW511x37. The two other monitoring wells that have recent increasing trends of TCE concentrations (MW522x37 and PZ07Sx37) are located upgradient from and adjacent to active extraction wells, which should capture the elevated concentrations of TCE. The increasing TCE concentrations observed in the monitoring wells will likely represent groundwater contamination that is being drawn toward the extraction system.
4.	COC concentrations in most monitoring wells remain stable or are decreasing. COC concentrations in most extraction wells are also declining.
5.	TCE continues to be the most widespread COC at the WIOU GET; TCE is also detected at the highest concentrations. Neither TPH-G nor TPH-D, although COCs at many WIOU sites, appears to be widespread in the WIOU GET area.
6.	VOC concentrations in the northern portion of the WIOU plume at SD034 have been decreasing. With the exception of MWSNSM4x37, total chlorinated VOC concentrations in wells monitored during the 2001-2002 GSAP are below 100 µg/L. VOC concentrations are declining in MWSNSM4x37 (see Figure 6.1-6) and in the other SD034 monitoring and extraction wells. However, elevated concentrations of TPH-D and TPH-G continue to be detected at monitoring wells MW02x34 and MW04x34.
7.	Extraction well EW700x37 has had a trend of decreasing TCE concentrations (Figure 6.1-5), and total VOC concentrations at this extraction well have declined to less than 10 µg/L. This extraction well is located on the western edge of the plume. Total VOC concentrations in nearby monitoring wells MW525x37 and MWSNSM3x37 are also less than 10 µg/L.
8.	Extraction well EW593x36 is also located along the western edge of the WIOU plume. TCE concentrations have been declining in this extraction well (Figure 6.1-5), and total VOCs have declined in this well to less than 10 µg/L. Monitoring wells upgradient and crossgradient of this extraction well include MW762x39, MW872x36, and PZ03x36. Total VOCs detected in the 2001-2002 GSAP were less than 1 µg/L in all three of these wells. Total VOC concentrations at Piezometer PZ06Sx36, located approximately 70 feet downgradient of EW593x36, remain slightly above 100 µg/L. However, concentrations of TCE have been declining at PZ06Sx36 (Figure 6.1-5), and no VOCs were detected in the deep piezometer PZ06Dx36 paired with it during the 2001-2002 GSAP.
9.	Groundwater contamination in the vicinity of WABOU Sites SS041 and SD043 appears to be minimal. Heptachlor epoxide, the only COC at SS041, has not been detected at the site or neighboring site SD043 from 1997 through 2002. TCE is the only COC at SD043, and TCE concentrations detected in the vicinity of Sites SS041 and SD043 remain below 5 µg/L.
10.	Two surface water locations, WBUC-3 and WBUC-4, along the West Branch of Union Creek are sampled as part of the GSAP. As illustrated by the TCE time series plot for WBUC-4 (Figure 6.1-5), VOC concentrations in the creek have declined. TCE and cis-1,2-DCE concentrations detected at both locations in the 2001-2002 GSAP were below IRGs. No other COCs were detected in the surface water samples.

The migration of TCE-contaminated groundwater in the area of WIOU GET systems has been approximated using a series of mixing cell calculations simulating the flushing of uncontaminated groundwater through contaminated portions of the aquifer and extraction of contaminated groundwater by the extraction wells. Series of mixing cells were aligned with flowtubes converging to the extraction wells for the purposes of the calculations.

The configuration of flowtubes and rates of groundwater flow through flowtubes were based on the results of a steady simulation of groundwater flow performed using the updated Basewide Groundwater Flow Model (Appendix A). The initial (present-day) distribution of TCE in the WIOU was estimated using groundwater quality data collected during the May 2002 GSAP monitoring event (Figure 6.1-4).

Simulations of TCE migration based on mixing cell (flushing) calculations are shown on Figure 6.1-6. The calculations suggest that TCE concentrations in the area of the WIOU are likely to remain above 5 µg/L in excess of 100 years under current operating conditions. In addition, Figure 6.1-6 illustrates that there is a potential for some groundwater contamination to migrate past the extraction system at some time 30+ years in the future. However, this does not indicate that failure will occur – the Migration Control objective is designed to contain TCE contamination at concentrations greater than 100 µg/L. These elevated concentrations are not predicted to migrate past the extraction system. TCE that does migrate past the GET system appears to stabilize the MNA area south of the GET system.

The results presented are based on the existing configuration of extraction wells in the WIOU, designed to control the migration of contaminated groundwater, rather than accelerate cleanup. System optimization, including the installation of additional extraction wells in high-concentration areas, will reduce cleanup times.

The results presented represent best estimates of possible outcomes over long periods of time under current operating conditions, and are provided as a potential basis for identifying and prioritizing areas of future investigation. These results are based on recent refinements to the Basewide Groundwater Flow Model (Appendix A). Predictions of TCE contamination potentially migrating past the GET system should be viewed as one possible outcome that should be assessed using GSAP and other field data on an ongoing basis.

By way of contrast, time-to-cleanup estimates made during the FS indicated that TCE concentrations would drop to 5 µg/L in the WIOU at times varying by site from about 60 years (SD036) to 85 years (SD033) to 111 years (SD037) (Radian Corporation, 1996). Current estimates indicate that cleanup will probably take longer than this. However, optimization activities may reduce this time (see Section 6.1.6).

Current data does not show that the WIOU GET system is failing to achieve design capture of groundwater contamination. If there is some future indication that TCE is migrating beyond the extraction system, then the appropriate agencies should address the issue at that time.

6.1.6 Opportunities for Optimization

Opportunities for optimization, either in terms of reduced time to cleanup or reduced O&M cost, for the WIOU system are identified in this section. Potential opportunities include extraction well flow adjustments to increase mass removal rate, and the implementation of in situ technologies to reduce time to cleanup. In addition, existing site data at SD037 should be addressed to confirm that the extent of contamination is fully characterized. If data gaps are identified, then additional data should be collected to optimize the remedial action in this area.

Potential areas for optimization is discussed briefly in the following sections. Table 6.1-6 summarizes the opportunities for optimization discussed below. There are no recommendations for modification to the existing treatment and transfer system, other than discontinuation of vapor treatment as discussed above.

Optimization may lead to cost savings in several ways. For example, increasing the rate of mass removal will reduce the time needed to clean the contamination, with corresponding savings in LTO. Decreasing the size of the plume may allow the Air Force to shut down portions of the extraction system, leading to reduced maintenance costs. As the plume is cleaned, other savings will follow, including reduced O&M, carbon costs, and electrical costs.

TABLE 6.1-6
Recommendations for Optimization in the WIOU
Groundwater Five-Year Review, Travis Air Force Base, California

Recommendations for Optimization
1. Use groundwater modeling to reduce pumping in existing extraction wells and potentially stop pumping altogether in existing extraction wells.
2. Use groundwater modeling to identify locations for one or more new extraction wells that are closer to source areas.
3. Install additional monitoring wells if necessary to monitor the performance of new extraction wells.
4. Consider in situ technologies to reduce source area contaminant mass.

6.1.6.1 Extraction Well Flow Adjustment

Several wells in the WIOU system have been identified as potential candidates for flow reduction. Prior to the implementation of any flow changes, the groundwater model will be used to evaluate the potential impacts on the overall system hydraulic capture. However, based on groundwater contours and the flow lines generated by the groundwater model for previous designs, it appears that flow reduction from the wells listed below would not have a detrimental effect on overall plume capture:

- **EW700x37 –** Extraction well EW700x37 has had a trend of decreasing TCE concentrations (Figure 6.1-5), and total VOC concentrations at this extraction well have declined to less than 10 µg/L. This extraction well is located on the western edge of the plume. Total VOC concentrations in nearby monitoring wells MW525x37 and MWSNSM3x37 are also less than 10 µg/L.

- **EW593x36 –** Extraction well EW593x36 is also located along the western edge of the WIOU plume. TCE concentrations have been declining in this extraction well (Figure 6.1-5), and total VOCs have declined in this well to less than 10 µg/L. Monitoring wells upgradient and crossgradient of this extraction well include MW762x39, MW872x36, and PZ03x36. Total VOCs detected in the 2001-2002 GSAP were less than 1 µg/L in all three of these wells. Total VOC concentrations at piezometer PZ06Sx36, located approximately 70 feet downgradient of EW593x36, remain slightly above 100 µg/L. However, concentrations of TCE have been declining at PZ06Sx36 (Figure 6.1-5), and no VOCs were detected in the deep piezometer PZ06Dx36 paired with it during the 2001-2002 GSAP. Further, this area would likely be within the capture zone of other downgradient extraction wells.

- **EW542x41 and EW555x43 –** Groundwater contamination in the vicinity of WABOU Sites SS041 and SD043 appears to be minimal. Heptachlor epoxide, the only COC at SS041, has not been detected at the site or neighboring site SD043 for at least 5 years. PCB-1254 has also not been detected at the site in GSAP sampling conducted between 1997 and 2001. TCE is the only COC at SD043, and TCE concentrations detected in the vicinity of Sites SS041 and SD043 remain below 5 µg/L.

6.1.6.2 Installation of New Extraction Wells

It might also be possible to increase the mass removal rate in the WIOU by installing additional wells in areas of high contaminant concentration. Potential well locations for increased mass removal include the following:

- Downgradient of MW524x37, where TCE still greater than 1,000 µg/L
- Near MW513x37, which is near the core of the >100-µg/L plume

If stakeholders agree that additional extraction wells will speed up remediation, then a project will be programmed, a design modification completed, and the wells installed.

6.1.6.3 Installation of New Monitoring Wells

Additional monitoring wells may be needed to monitor remedial progress in new extraction wells.

6.1.6.4 Implementation of In Situ Technologies

In situ technologies could decrease the time to cleanup, if implemented in the WIOU area. The WIOU is located in an active area onbase. The surface is largely covered with buildings, parking lots, and roads. Discussion of the application of any in situ technology in this area must consider potential impacts to Base activities. One of the most passive technologies available is enhanced bioremediation. As previously described in Section 4.1.6, bioremediation has the potential to significantly decrease contaminant mass in place at the site and therefore, reduce the time the cleanup. Enhanced bioremediation can comprise a number of strategies, but generally consists of the injection of an electron donor into the subsurface to stimulate biological reductive dechlorination. This technology is potentially effective for all of the contaminants found in the WIOU.

6.1.7 Technical Assessment

6.1.7.1 Is the Remedy Functioning as Intended by the IROD?

Yes. Based on groundwater quality data, groundwater elevation data, and the results of groundwater modeling, the Source Control and Migration Control objectives are being met in the WIOU. All monitoring wells containing TC concentrations exceeding 100 µg/L are within the hydraulic capture zone. Ongoing monitoring will ensure that no contamination exceeding this concentration migrates past the existing GET system. Varying vertical hydraulic gradients and modeling also indicate that there are no issues in the WIOU with regard to vertical distribution or movement of contaminants. The plume has been fully delineated in the WIOU.

6.1.7.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There is currently no complete exposure pathway to human or ecological receptors. No new pathways have been identified. Changes in land use on or near these sites that would affect protectiveness are not anticipated, and no new contaminants or source areas have been identified.

6.1.7.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. The remedy is functioning as planned. Risks to potential ecological or human receptors have been adequately addressed, and the WIOU is not potentially subject to natural disasters.

6.1.8 Statement of Protectiveness

The GET remedy at the WIOU is expected to be or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

6.1.9 References

CH2M HILL. 2002a. *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report.* Travis AFB, California. November.

CH2M HILL. 2001e. Final *West/Annexes/Basewide Operable Unit Natural Attenuation Assessment Work Plan.* Travis AFB, California.

CH2M HILL. 2000. *Re-evaluation of Soil and Groundwater Contamination at Building 916 (SD043).* Technical Memorandum. February.

CH2M HILL. 1999d. *West Industrial Operable Unit Interim Groundwater Remedial Design/Remedial Action.* Travis AFB, California.

Radian Corporation. 1996. Final *North/East/West Industrial Operable Unit Feasibility Study*. Installation Restoration Program. Travis AFB, California. September.

Travis AFB. 1999. Final *Groundwater Interim Record of Decision for the West/Annexes/Basewide Operable Unit.* Installation Restoration Program. Travis AFB, California. 24 June.

Travis AFB. 1997. Final *Groundwater Interim Record of Decision for the North, East, and West Industrial Operable Unit.* Installation Restoration Program. Travis AFB, California. December.

URS Group. 2002e. Final *Central Groundwater Treatment Plan Quarterly Report, Third Quarter 2002*. October.

URS Group. 2002f. *Central Groundwater Treatment Plant 2001 Annual Report*. January.

U.S. Air Force. 2002. Final Soil Record of Decision for the *West/Annexes/Basewide Operable Unit*. December.

Figure
6.1-1 WIOU GET Site Map
11 x 17 color

Figure 6.1-1 continued

Figure
6.1-2 WTTP Total VOC Concentrations over Time
8.5 x 11 b&w

Figure
6.1-3 Groundwater Elevations Measured at the WIOU GET during May 2002
11 x 17 color

Figure 6.1-3 continued

Figure 6.1-4 TCE Distribution at the WIOU GET
C Sheet color

Figure 6.1-4 continued

Figure
6.1-5 TCE Chemical Time Series Plots for WIOU GET
8.5 x 11 b&w
(page 1 of 2)

Figure 6.1-5 continued
(page 2 of 2)

Figure
6.1-6 Time to Cleanup Simulation for TCE WIOU
11 x 17 color

Figure 6.1-6 continued

6.2 WIOU Monitored Natural Attenuation Assessment

6.2.1 Site Description

MNA was selected for assessment during the interim period in the southern portions of two WIOU sites (SD033 and SD037) in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). These sites, together with POCO Site SS014 (Subsite 1), were combined for the assessment because of their proximity and similar site conditions. Figure 6.2-1 shows the sites features and locations of monitoring wells in the southern WIOU.

Three subareas of Site SD033 were identified for MNA assessment in the *Groundwater IROD for the NEWIOU*: Facility 810, the South Gate Area, and Facility 1917. Facility 810 was later dropped from MNA assessment because it is within the hydraulic capture zone of the WIOU GET system. The *WIOU Natural Attenuation Assessment Work Plan* concluded that no further action was required in the South Gate Area or Facility 1917 (CH2M HILL, 2001e). However, the southern portion of SSS 2, which lies outside the capture zone of the GET system but is part of SD033, was later added for ongoing MNA assessment.

Several subareas of Site SD037 were also identified for natural attenuation assessment in the *Groundwater IROD for the NEWIOU*: portions of the plume near Facilities 919, 977, and 981, and the Area G Ramp. However, it later became apparent that groundwater in the vicinity of Facilities 919 and 981 would be captured by the WIOU GET system. Therefore, only portions of the plume near Facility 977 and the Area G Ramp were included in the MNA assessment. Facility 977, located east of Ragsdale Street near the southwestern corner of the WIOU, is a large air freight terminal constructed in 1972. Hydraulic equipment is used here to load and unload cargo, which is stored inside the facility. TPH-D was reportedly released from hydraulic rams in the past. The rams were replaced, and the new rams are checked periodically for leaks. TCE was detected in the groundwater at this site, but is believed to have originated from the sanitary sewer (also part of SD037) (CH2M HILL, 2002a).

The Area G Ramp is located southeast of Facility 977 in the southwestern portion of the WIOU. The ramp is a large, paved area on which aircraft are parked. Aircraft fueling is accomplished with a hydrant system (the 900 Ramp Hydrant System) that consists of an underground pressurized pipeline and aircraft fueling locations. At each fueling location, a riser pipe can be attached to a pump truck. The pump trucks move fuel from the hydrant system to the fuel tanks of aircraft. TCE was detected in the groundwater at this site, but believed to have originated from the sanitary sewer (also part of SD037) (CH2M HILL, 2002a). Table 6.2-1 lists the COCs for the MNA portions of Sites SD033 and SD037.

TABLE 6.2-1
Chemicals of Concern at Sites SD033 and SD037
Groundwater Five-Year Review, Travis Air Force Base, California

Sites	COCs
SD033	TCE[a], 1,1-DCE, 1,2-DCE, cis-1,2-DCE, TPH-G, TPH-D
SD037	TCE[a], PCE, cis-1,2-DCE, benzene, TPH-G, TPH-D

[a]TCE is the indicator chemical for the sites.

Two subsites of Site SS014 (Subsite 1 – Jet-fuel Spill Area and the Subsite 4 – Abandoned Aviation Gasoline Pipeline) are also included in the South WIOU MNA assessment. These sites were not included in the *Groundwater IROD for the NEWIOU*, but are being addressed as part of the POCO program at Travis AFB. Free-product removal and MNA were selected as remedies for the Jet-fuel Spill Area, and MNA was selected as the remedy for the Abandoned Aviation Gasoline Pipeline. Because these SS014 subsites are contiguous with the SD033 and SD037 subareas identified for MNA in the southern WIOU area, they are collected together for monitoring as part of the WIOU MNA assessment. Primary contaminants at the SS014 subsites are petroleum hydrocarbons (TPH-D; TPH-G; and benzene, toluene, ethylbenzene, and xylene) (CH2M HILL, 2002a).

6.2.2 Site History and Status

MNA assessment has been selected for the southern portions of Sites SS014, SD033, and SD037. The northern portions of these sites, including several other WIOU sites, were selected for groundwater extraction and treatment. Because combining remedial response actions for sites proximate to one another was the best approach to achieve cleanup goals, with the approval of the regulatory agencies and the public, a GET system was designed to include all of the sites located within the northern WIOU. This system became fully operational in April 2001, after an initial startup period beginning 31 January 2001. The system was designed to capture groundwater contaminated with TCE at concentrations greater than 100 µg/L (CH2M HILL, 2002a).

In 2000, the southern WIOU underwent a preliminary natural attenuation assessment, as specified in the *Natural Attenuation Assessment Plan* (CH2M HILL, 1998b). The natural attenuation assessment was later documented in the *WIOU Natural Attenuation Assessment Work Plan* (CH2M HILL, 2001e). The *Natural Attenuation Assessment Work Plan* concluded that MNA might be a viable option for the southern WIOU, and recommended ongoing monitoring for COCs during the interim period to confirm plume stability and support a future evaluation of MNA as a final remedy for the site.

The *Natural Attenuation Assessment Work Plan* also identified monitoring wells for this ongoing monitoring and specified that laboratory analyses be performed for VOCs, TPH-G, and TPH-D (site COCs). The *Natural Attenuation Assessment Work Plan* required 1 year of quarterly sampling for COCs in the southern WIOU to establish baseline conditions, after which the data are reviewed and the sampling frequency re-evaluated. As of the May 2002 event, the southern WIOU had completed its first year of sampling. Sampling frequency thereafter was based on the Decision Tree (CH2M HILL, 2001a).

6.2.3 Interim Remedial Action

The downgradient portions of Sites SD033 and SD037 were designated for MNA assessment in the *Groundwater IROD for the NEWIOU* (Travis AFB, 1997). The downgradient portion of SS014 was designated for MNA in the *SS014 POCO Work Plan* (CH2M HILL, 1999e). As mentioned above, the Air Force decided to combine these sites for MNA assessment because they are geographically contiguous, and because they have similar COCs. As part of the preparation of a *Natural Attenuation Assessment Work Plan* for the south WIOU, several monitoring wells were installed to facilitate ongoing groundwater monitoring. This monitoring is part of the natural attenuation assessment; MNA has not been selected at SD033 or SD037, but is being assessed during the interim period. The main objective of MNA is Migration Control. The ongoing assessment is designed to measure the success of this objective, and determine whether the downgradient portion of the plume in the southern WIOU is continuing to migrate, or is stable. Monitoring is conducted as part of the GSAP, and a conclusion is drawn annually in the GSAP Annual Report. Currently, there are insufficient data to draw conclusions regarding MNA in the WIOU area. Ultimately, when sufficient data are available, a Natural Attenuation Summary Report will be prepared that will recommend whether MNA should be selected as the final remedy at these sites (CH2M HILL, 1998b).

6.2.4 Groundwater Monitoring

The following sections summarize the results of groundwater monitoring conducted as part of the GSAP to support evaluations of plume stability and the viability of MNA as a final remedy for the southern portions of Sites SD033 and SD037 in the WIOU. A comprehensive description of hydrologic and contaminant data collected at the sites is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2002a).

6.2.4.1 Hydraulic Data

The hydrogeology and general hydrologic conditions in the WIOU are described in Section 6.1.5.

Table 6.2-2 presents the conclusions that have been drawn from review of hydraulic data concerning hydrologic conditions in the southern portions of Sites SD033 and SD037.

TABLE 6.2-2
Conclusions Concerning Hydrologic Conditions in the Southern WIOU
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is 10 to 17 feet bgs.
2.	Groundwater flow is southerly based on available GSAP groundwater level measurements (Figure 6.2-2).
3.	Lateral hydraulic gradients are approximately 0.003 foot/foot in the southern WIOU.
4.	Vertical hydraulic gradients are small in the southern WIOU. No significant vertical hydraulic gradients (greater than ± 0.05 foot/foot) were recorded at the MW116x37/MW310x07 well pair during the 2001-2002 GSAP.

6.2.4.2 Groundwater Quality Data

Figure 6.2-3 shows TCE concentrations detected in the May 2002 GSAP event within the WIOU MNA area. Figures 6.2-4, 6.2-5, and 6.2-6 present time series plots of TCE, TPH-D, and TPH-G at selected WIOU MNA monitoring wells.

The following wells are included for ongoing MNA monitoring in the South WIOU area:

- Trigger Wells: MW1208x37 and MW722x37
- Point-of-compliance Wells: MW1209x37, MW723x37, and MWS1Mx37
- Guard Wells: MW05x14, MW116x37, MW222x37, MW724x37, MW729x37, and MW730x37

The main objective of groundwater monitoring at MNA sites at Travis AFB is to verify plume containment during the interim period. Containment is the ultimate test of natural attenuation. If MNA is not effective in controlling migration, the Air Force and regulators will evaluate alternative remedies. Groundwater quality data collected from the monitoring network at the WIOU MNA support the conclusions summarized in Table 6.2-3.

TABLE 6.2-3
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	As illustrated on Figures 6.2-4, 6.2-5, and 6.2-6, COC concentrations are currently stable or declining in the trigger wells (MW1208x37 and MW722x37) and point-of-compliance wells (MW1209x37, MW723x37, and MWS1M2x37). The variation of TPH-G and TPH-D concentrations from nondetect to 100 µg/L is typical for these analyses, and no increasing trends are observed in the data.
2.	TCE was detected at a very low concentration for the first time in guard well MW730x37 in May 2002. TCE was previously detected for the first time in guard wells MW116x37 and MW724x37 in May 2001, and continued to be detected in these wells in 2002 (see Figure 6.2-4). All of the TCE concentrations detected in these wells during 2002 remain very low (less than 1 µg/L). Ongoing monitoring will be performed to assess whether migration is occurring.
3.	Petroleum hydrocarbons, including benzene, TPH-G, and TPH-D, continue to be found at high concentrations in guard well MW05x14, which provides monitoring for the Abandoned Aviation Gasoline Pipeline, a subsite of POCO Site SS014. However, concentrations of benzene and TPH-G are declining over time in this well, and TPH-D concentrations are stable, and may show a slight declining trend. Figures 4.6-5 and 4.6-6 present historical TPH-D and TPH-G concentrations at this well.
4.	TPH-D and TPH-G were also detected above IRGs in two other downgradient guard wells (MW222x37 and MW724x37). However, the historical record indicates that these petroleum hydrocarbons are detected sporadically and at variable concentrations in these wells (Figures 6.2-5 and 6.2-6). Ongoing monitoring will reveal whether they represent a problem.
5.	Overall, groundwater contamination in the southern WIOU is stable, especially in the trigger and point-of-compliance wells. However, low detections of petroleum hydrocarbons and TCE in several of the downgradient guard wells will require ongoing attention. If concentration increases in these wells, implying that migration is occurring, then it may be necessary to install additional downgradient monitoring wells.

6.2.5 Technical Assessment

6.2.5.1 Is the Remedy Functioning as Intended by the IROD?

Yes. To date, the monitoring results appear to indicate that the MNA objective is being achieved; namely, for the most part, the plume is stable, and contaminant concentrations are declining. However, low concentrations of TCE and petroleum hydrocarbons in down-gradient wells will need to be watched. If concentrations increase in these wells, it will be an indication that the plume is continuing to migrate.

6.2.5.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are currently no exposure pathways to potential human or ecological receptors. The objective of MNA (Migration Control) is still valid, and the MNA assessment should continue.

6.2.5.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. The remedy is protective. Data to date do not indicate that migration is occurring.

6.2.5.4 Technical Assessment Summary

The ongoing assessment of MNA should continue in the south WIOU. However, uncertainty as to whether recent low detection s of COCs in downgradient wells implies that the plume is migrating or not suggests that the assessment should continue. Sufficient data are not yet available to conclude that MNA should be selected as the permanent remedy for this site.

Ongoing monitoring should continue as part of the GSAP. If contaminant concentrations continue to be detected in downgradient guard wells, then additional monitoring wells should be constructed, and the sampling frequency might need to be adjusted.

6.2.6 Statement of Protectiveness

The MNA remedy at the WIOU is expected to be or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

6.2.7 References

CH2M HILL. 2002a. *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report.* Travis AFB, California. November.

CH2M HILL. 2001a. Final *Long-term Operation Strategic Plan, Version 1.* Installation Restoration Program. Travis AFB, California. 10 December.

CH2M HILL. 2001e. Final *West/Annexes/Basewide Operable Unit Natural Attenuation Assessment Work Plan.* Travis AFB, California. January.

CH2M HILL. 1999e. Draft Final *SS014 Petroleum-Only Contaminated Work Plan.* Travis AFB, California. March.

CH2M HILL. 1998b. Final *Natural Attenuation Assessment Plan.* Installation Restoration Program. Travis AFB, California. August.

Travis AFB. 1997. Final *Groundwater Interim Record of Decision for the North, East, and West Industrial Operable Unit.* Installation Restoration Program. Travis AFB, California. December.

Figure
6.2-1 WIOU MNA Site Map
11 x 17 color

Figure 6.2-1 continued

Figure
6.2-2 Groundwater Elevations Measured at the WIOU MNA during May 2002
11 x 17 color

Figure 6.2-2 continued

Figure
6.2-3 TCE Distribution at WIOU MNA
11 x 17 color

Figure 6.2-3 continued

Figure
6.2-4 TCE Chemical Time Series Plots for WIOU MNA
8. x 11 b&w page 1 of 2

Figure 6.2-4 page 2 of 2

Figure
6.2-5 TPH-D Chemical Time Series Plots for WIOU MNA
8.5 x 11 b&w page 1 of 2

Figure 6.2-5 page 2 of 2

Figure
6.2-6 TPH-G Chemical Time Series Plots for WIOU MNA
8.5 x 11 b&w page 1 of 2

Figure 6.2-6 page 2 of 2

6.3 SS015 Monitored Natural Attenuation Assessment

6.3.1 Site Description

Site SS015 occupies 3.5 acres in the northwestern part of the EIOU. Figure 6.3-1 shows the locations of buildings, roads, and monitoring wells at the site. Three potential sources of groundwater contamination have been identified at Site SS015: Facility 550, Facility 552, and an area known as the Solvent Spill Area east of Facility 550.

Facility 550 is located south of Hangar Avenue. The facility housed a corrosion control shop, metals processing shop, and fiberglass shop beginning in 1952. Paints, paint thinners, methyl ethyl ketone, acids, and stripping wastes were used / generated at the facility. A floor drain connected to the sanitary sewer was used to discharge wastes in the corrosion control shop. Facility 550 is unoccupied at present and scheduled for demolition (Roy F. Weston, Inc., 1995).

Facility 552 is a fenced, bermed, concrete pad located a few feet south of Hangar Avenue and immediately east of Facility 550. Most recently, the facility was used as a hazardous waste collection area. Paint, chromic acid, and waste solvents generated during aircraft maintenance activities at Facility 550 were stored at Facility 552. From 1964 to 1980, radomes were stripped of paint in an area adjacent to Facility 552 (Roy F. Weston, Inc., 1995).

The Solvent Spill Area occupies 1.4 acres east of Facility 550. Paint was stripped from aircraft in the area for an undocumented period of time. Accidental releases included an estimated 100 to 150 gallons per month of either methyl ethyl ketone, toluene, and / or tetraethylene glycol dimethyl ether (tetraglyme) from work trays used to collect stripping wastes. Soil is visibly stained in the Solvent Spill Area in aerial photographs taken prior to 1970 (Roy F. Weston, Inc., 1995).

Table 6.3-1 lists Site SS015 COCs.

TABLE 6.3-1
Chemicals of Concern at Site SS015
Groundwater Five-Year Review, Travis Air Force Base, California

Site	COCs
SS015	TCE[a], PCE, cis-1,2-DCE, vinyl chloride, 1,4-dichlorobenzene, 1,2-DCA, bis(2-ethylhexyl)phthalate, nickel

[a]TCE is the indicator chemical for the site.

6.3.2 Site History and Status

The following investigations and actions have taken place at SS015:

- An IRP Phase I Records Search concluded that there was potential for contamination at the Solvent Spill Area (now a part of SS015) and that this site should be investigated further (Engineering Science, Inc., 1983).

- An IRP Phase II Confirmation / Quantification Stage 1 investigation was performed during 1985. As part of this investigation, three monitoring wells (MW-104 through

MW-106) were installed, and soil and groundwater samples were collected (Roy F. Weston, Inc., 1986).

- An IRP Stage 2 investigation was performed during 1987 and 1988. Three additional monitoring wells (MW-215, MW-216, and MW-306) were installed, and additional groundwater and soil samples were collected (Roy F. Weston, Inc., 1990).
- A RCRA Facility Assessment was performed in 1991 and 1992. At SS015, investigations included the installation of three additional monitoring wells (MW-237, MW-238, and MW-315) and the collection of soil and groundwater samples. Facilities 552, 808, and 1832 were identified for investigation at this time. A review of historical aerial photographs was also completed (Roy F. Weston, Inc., 1992).
- The RI was performed at SS015 during 1993 and 1994. Activities included soil, sediment, and groundwater sampling, and installation of one monitoring well (MW-1728). The RI recommended that SS015 be included in the FS (Roy F. Weston, Inc., 1995).
- Collection of groundwater samples began at SS015 as part of the GSAP in 1996, and samples have been collected at least semiannually since that time.
- MNA assessment was selected for SS015 as part of the NEWIOU FS and IROD at Travis AFB (Travis AFB, 1997).

In 1999, a predesign investigation was performed at SS015 as part of the preparation of the Natural Attenuation Assessment Work Plan for the site. Investigation activities included collecting in situ groundwater samples via HydroPunch® and Site Characterization and Analysis Penetrometer System sampling. The investigation also included a Gore-Sorber passive soil gas survey. This investigation discovered that VOC concentrations at SS015 were more elevated than originally expected. In addition, the plume was found to be distributed in a different direction than originally believed during the RI (CH2M HILL, 1999f).

The Air Force then decided, with the concurrence of the regulatory agencies, to perform an enhanced biodegradation treatability study at SS015. The treatability study involved injecting vegetable oil into the ground to provide electron donors for reductive dechlorination of chlorinated solvents. Phase I and Phase II of this study have been completed (Parsons Engineering Science, Inc., 2001; 2002).

The study results suggested that the presence of elevated sulfate concentrations at the site were limiting the effectiveness of the solvent dechlorination. Sulfate concentrations were observed to decrease over the course of the study, indicating that if additional vegetable oil were injected, sulfate would be sufficiently reduced to allow dechlorination of the solvents to occur. Additional study was recommended to assess the effectiveness of ongoing vegetable oil injection (Parsons Engineering Science, Inc., 2002). Additional groundwater sampling is scheduled for March 2003.

In 2002, the Air Force decided to construct a new building at the site. Steps are being taken to ensure the future safety of building occupants, including excavating and removing contaminated soil and installing a vapor barrier in the foundation to prevent contaminated soil gas from gaining access to the building. In addition, the Air Force is installing several new monitoring wells along the perimeter of the site.

6.3.3 Interim Remedial Action

6.3.3.1 Interim Remedial Action Objective

Alternative 2—Natural Attenuation / Monitoring was selected as the IRA at SS015. As at other MNA sites, MNA is designated for assessment at SS015 during the interim period. The selection of MNA as a permanent remedy is deferred to the future, when a decision will be made whether to select MNA as a permanent remedy.

As mentioned in Section 6.3.2, an SS015 Natural Attenuation Assessment Work Plan was never prepared because the nature and extent of contamination at SS015 was found to be different than believed at the conclusion of the RI. A Vegetable Oil Injection Treatability Study has been underway at SS015. However, this study is being terminated due to construction of a new refueling vehicle maintenance facility. Some monitoring wells will be destroyed during construction. However, the most critical wells, including source area well MW216x15, will be preserved. In addition, the Air Force intends to install new monitoring wells along the downgradient site boundary during construction. Eventually, the Air Force will need to perform additional investigations to assess whether MNA is an appropriate remedy at SS015.

6.3.3.2 Remedy Description

Groundwater monitoring is being performed as part of the GSAP. Currently, five monitoring wells are sampled at SS015. This sampling program may change after the new building construction begins at the site. Wells currently sampled include the following (CH2M HILL, 2002a):

- **Upgradient Well –** MW238x15
- **Plume Well –** MW216x15
- **Crossgradient Wells –** MW105x15 and MW306x15
- **Downgradient Well –** MW104x15

6.3.4 Groundwater Monitoring

The following sections summarize the hydrogeology of Site SS015 and results of groundwater monitoring conducted as part of the GSAP to support evaluations of plume stability and the viability of MNA as a final remedy for the site. A comprehensive description of hydrologic and contaminant data collected at SS015 is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2002a).

6.3.4.1 Site Hydrogeology

Site SS015 is located on the eastern flank of a ridge of Markley Sandstone. Nortonville Shale underlies SS015 to the east and forms the bedrock in this area (Figures 2-1 and 2-2). The area was subsequently overlain by alluvium as described in Section 2.1. Alluvium is approximately 20 feet thick at SS015 (based on drilling) and is composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay. Sand and silty sand were derived from nearby Markley Sandstone.

6.3.4.2 Hydraulic Data

On a seasonal basis, the elevation of the water table varies 2 to 4 feet. However, no long-term trends in the elevation of the water table have been observed at the site.

Contours showing the elevation of the water table at SS015 during the May 2002 GSAP monitoring event are shown on Figure 6.3-2. Vertical hydraulic gradients have been evaluated at the site using groundwater level measurements in shallow and deep well pairs.

Table 6.3-2 presents conclusions concerning hydrologic conditions at SS015.

TABLE 6.3-2
Conclusions Concerning Hydrologic Conditions at SS015
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is approximately 10 feet bgs.
2.	Groundwater was believed in the RI to flow to the south in this area. However, groundwater flow is actually toward the northeast (locally) due to the proximity and orientation of a nearby subsurface ridge of Markley Sandstone.
3.	Lateral hydraulic gradients are approximately 0.0004 foot/foot in the area of SS015.
4.	One of two shallow/deep well pairs at SS015 showed significant vertical hydraulic gradients (greater than ± 0.05 foot/foot) during the 2001-2002 GSAP: well pair MW105x15 and MW306x15 (downward). Downward hydraulic gradients at this location may be due to the proximity and orientation of Markley Sandstone outcrop, which causes the groundwater regime in this area to act as a recharge zone.

6.3.4.3 Groundwater Quality Data

Figure 6.3-3 shows TCE concentrations detected in the May 2002 GSAP event at Site SS015. Figures 6.3-4, 6.3-5, and 6.3-6 present time series plots of TCE, PCE, and vinyl chloride concentrations over time in selected SS015 monitoring wells, respectively.

As described above, after the RI and the IROD, it was discovered that the degree and the extent of contamination at SS015 were greater than originally thought. The groundwater flow direction was originally misunderstood, and most of the existing SS015 monitoring wells are in inappropriate positions for plume monitoring. Only one monitoring well (MW216x15) is located within the plume. Thus, drawing conclusions about groundwater quality at the site is difficult.

Groundwater samples collected during the Site Characterization and Analysis Penetrometer System investigation found that TCE concentrations within the plume were more elevated than originally thought. For example, TCE was detected at a maximum concentration of 3,400 J µg/L in one in situ sample (CH2M HILL, 1999f).

However, as mentioned in Section 6.1, an additional site investigation was performed, better defining the extent of the plume to the east (CH2M HILL, 1999f). In addition, an enhanced biodegradation treatability study, using vegetable oil as a carbon donor, is being performed at the site (Parsons Engineering Science, Inc., 2001; 2002). Groundwater quality data collected from the monitoring network at SS015, data from the 1999 site investigation, and the biodegredation treatability study support the conclusions summarized in Table 6.3-3.

TABLE 6.3-3
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	The former Solvent Spill Area appears to be the main contaminant source area at this site, although the actual source has yet to be identified.
2.	TCE concentrations have been rising over time in MW216x15. This is currently the only monitoring well located within the plume. This indicates that the plume is actively migrating.
3.	Currently, insufficient monitoring wells are present to monitor plume migration at SS015.
4.	The extent of contamination has not been defined. Monitoring points installed and sampled as part of the treatability study indicate that the VOC plume extends at least 100 feet to the northeast of monitoring well MW216x15 (Parsons Engineering Science, Inc., 2001; 2002).
5.	Daughter products of reductive dehalogenation of TCE and PCE, including cis-1,2-DCE and vinyl chloride, were detected in well MW216x15 during the 2001-2002 GSAP. This suggests that reductive dehalogenation has occurred. However, the concentrations of vinyl chloride are currently much lower than historical concentrations.
6.	The Phase II Vegetable Oil Injection Treatability Study concluded that the presence of naturally occurring sulfate at the site is interfering with reductive dechlorination of chlorinated compounds.

6.3.5 Technical Assessment

6.3.5.1 Is the Remedy Functioning as Intended by the IROD?

Yes. The MNA assessment was not completed because the nature and extent of contamination was discovered to be different than originally believed. A treatability study has been occurring for the past 3 years. Although the final data have not been received from the treatability study, it appears that significant uncertainties still remain at this site. However, the Air Force will program additional investigation to address the remaining uncertainties, will assess the feasibility of MNA, and will implement the appropriate remedy. The success of MNA at meeting performance objectives will be documented in the National Attenuation Assessment Report. All natural attenuation indicators, including biodegradation indicators, will be assessed in the National Attenuation Assessment Report. If MNA is not appropriate, then another remedy, such as GET, will be evaluated and implemented. Access to contamination is limited via the site's location and institutional controls. Because future action is pending, this remedy is considered protective on an interim basis.

6.3.5.2 Are the Assumptions Still Valid?

Yes. The original assumptions were based on a Conceptual Site Model that has since been revised. However, as discussed above, the Air Force is responding to the new site understandings. There has been a change in land use, in that a building is under construction at the site. However, contaminated soil was removed prior to construction, and an impermeable liner is being installed in the foundation to prevent migration of soil vapor. No new exposure pathways or contaminants have been identified. Any contamination migrating away from SS015 should be captured by the downgradient extraction system at SS016. The site is located within the interior of the Base, and institutional controls are in place to prevent exposure to the groundwater. Ongoing monitoring will track the movement of contaminants.

6.3.5.3 Has Any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. As discussed in this section, new data have been developed that reveal that the magnitude and extent of contamination are different than expected. However, there are no new risks to human or ecological receptors, and the site is not subject to natural disasters.

6.3.5.4 Technical Assessment Summary

Additional investigation is needed to resolve remaining uncertainties at SS015. For example, significant uncertainties include the location and nature of the source of the contamination, the downgradient extent of contamination, and whether or not the plume is actively migrating. After the investigation is complete, then the selection of remedy should be re-visited. Remedial action objectives should also be developed again. Natural attenuation might still be a viable remedy, but further characterization is needed.

6.3.6 Statement of Protectiveness

The MNA remedy at Site SS015 is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

6.3.7 References

CH2M HILL. 2002a. *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report.* Travis AFB, California. November.

CH2M HILL. 1999f. Draft Technical Memorandum: *Summary of the Site SS015 Investigation at Travis AFB, California.* October.

Engineering Science, Inc. 1983. *Installation Restoration Program—Phase I Records Search, Travis AFB, California.*

Parsons Engineering Science, Inc. 2001. Draft *Phase I Field Feasibility Test for In-Situ Bioremediation of Chlorinated Solvents Via Vegetable Oil Injection at Site SS015.* June.

Parsons Engineering Science, Inc. 2002. Final *Phase II Field Feasibility Test for In-Situ Bioremediation of Chlorinated Solvents Via Vegetable Oil Injection at Site SS015.* March.

Roy F. Weston, Inc. 1995. Final *Remedial Investigation Report, East Industrial Operable Unit, Travis AFB, California.* October.

Roy F. Weston, Inc. 1992. *Site Characterization Summaries for Travis AFB, California. Volume 3: Draft RCRA Facility Assessment.* September.

Roy F. Weston, Inc. 1990. *Installation Restoration Program, Draft Technical Report, Volumes I-VII, Stage 2. Travis AFB, California.* January.

Roy F. Weston, Inc. 1986. *Installation Restoration Program, Phase II Confirmation/Quantification Stage 1, Travis AFB, California.* April.

Travis AFB. 1997. Final *Groundwater Interim Record of Decision for the North, East, and West Industrial Operable Unit, Travis Air Force Base.* December.

Figure
6.3-1 SS015 Site Map
8.5 x 11 color

Figure 6.3-1 back

Figure
6.3-2 Groundwater Elevations Measured at SS015 during May 2002
8.5 x 11 color

Figure 6.3-2 back

Figure
6.3-3 TCE Distribution at Site SS015
8.5 x 11 color

Figure 6.3-3 back

Figure
6.3-4 TCE Chemical Time Series Plots for SS015
8.5 x 11 b&w

Figure
6.3-5 PCE Chemical Time Series Plots for SS015
8.5 x 11 b&w

Figure
6.3-6 Vinyl Chloride Chemical Time Series Plots for SS015
8.5 x 11 b&w

6.4 DP039 Remediation Systems and MNA Assessment

6.4.1 Site Description

Building 755 is located in the northern portion of the WABOU on the north side of Ellis Drive, about 1,000 feet east of Dixon Avenue (see Figure 6.4-1). Historically, Building 755 was used for testing rocket engines. Since 1968, Building 755 has been the location of the Travis AFB Battery and Electric Shop. The DP039 site consists of a former rock-filled acid-neutralization sump located approximately 65 feet west of Building 755, and a former leach field west of the sump.

Operations at Building 755 include recharging and dismantling lead-acid and nickel-cadmium batteries. Rinsate from recharged batteries and battery wastes is neutralized, collected in drums, and transported to an accumulation point at Building 1365 for disposal. The Electric Shop also services and tests constant-speed drives. These drives are drained of oil and wiped clean. Waste oil is containerized and disposed offsite. Generators have also been cleaned and tested in the Electric Shop since 1968. The cleaning and testing generates waste oil, which is containerized and transported for offbase disposal.

In the past, chlorinated solvents were also used for cleaning generators. Prior to 1978, battery acid solutions and solvents were reportedly discharged into a sink inside Building 755 that drained into the sump and leach field. This practice was discontinued in 1978, when the pipeline to the sump was dismantled and reconnected to the sanitary sewer system. Solvent wastes were also containerized and transported for offbase disposal after 1978. The sump and leach field have been inactive since that time.

In July 1993, the sump was removed and disposed of offbase. The sump was 8 feet long, 8 feet wide, and 4 feet deep. The sump area was lined with visqueen and backfilled with clean soil. Figure 6.4-1 shows the site features and the location of the monitoring wells at Site DP039 (CH2M HILL, 2003a).

Table 6.4-1 presents the COCs at Site DP039.

TABLE 6.4-1
Chemicals of Concern at Site DP039
Groundwater Five-Year Review, Travis Air Force Base, California

Site	COCs
DP039	TCE, 1,1-DCE, 1,2-DCA, 1,1,1-TCA, 1,1,2-TCA, PCE, methylene chloride, bromodichloromethane, acetone

6.4.2 Site History and Status

The WABOU RI concluded that VOCs are present in groundwater at and downgradient of the former sump area. TCE concentrations beneath the sump were sufficiently elevated to imply that residual concentrations of liquid-phase TCE were present beneath the sump. A groundwater TCE plume is now known to extend over 2,000 feet downgradient from the former sump.

The *Groundwater IROD for the WABOU* selected two IRA alternatives at DP039: (1) source area and groundwater extraction, and treatment with MNA for the downgradient portion of the plume; and (2) containment, treatment, and discharge (Travis AFB, 1999). Source Control was selected at DP039 because of the suspected presence of residual liquid-phase TCE beneath the sump.

To identify innovative technologies to promote the cleanup of dissolved solvents and to test their performance site-specific conditions, three treatability studies have been performed or are currently underway at DP039. An SVE and vacuum dewatering treatability study to assess the effectiveness of a 2-Phase® groundwater and SVE system for removing VOCs at the former sump area has been completed. Over the duration of the study, 495 pounds of total VOC mass were removed from the source area (CH2M HILL, 1999g). A groundwater/ soil vapor DPE system was later installed and became operational in February 2001.

A Permeable Reactive Treatment Wall Treatability Study was completed by the Air Force in June 2002. As part of that study, a subsurface iron filings permeable reactive wall was constructed downgradient from the source area. Data collected during the study demonstrated that the wall is only marginally successful at decreasing the dissolved-phase COCs. For example, TCE and 1,1-DCE concentrations are about 8,000 μg/L and 1,500 μg/L, respectively, upgradient of the reactive wall; and both have decreased to about 10 μg/L within the reactive wall (MACTEC, Inc., 2002).

A Phytoremediation Treatability Study is also in progress at DP039. This study assesses the use of engineered tree plantings to hydraulically control and remove VOC mass from the groundwater. There are insufficient data from this study to determine whether this technology can effectively stabilize a highly concentrated solvent plume, so that additional data will be collected in the future.

A predesign MNA investigation was performed in the downgradient portion of the plume, as part of a preliminary assessment of natural attenuation at DP039. This investigation included the installation of several new downgradient monitoring wells. A *DP039 Natural Attenuation Assessment Work Plan* was then prepared, which specifies ongoing monitoring during the interim period as part of the MNA assessment (CH2M HILL, 2001f).

6.4.3 DP039 Active Remediation Systems

The active remediation at DP039 currently consists of one DPE well, EW563x39 (Figure 6.4-1), located in the former sump area. The objective of this action is source area removal. Extracted soil vapor and groundwater from this well are conveyed in separate pipelines to the WTTP where the vapor is treated and discharged, and the groundwater is transferred to the CGWTP for treatment. Groundwater is extracted using a submersible pump, and soil vapor is extracted by applying vacuum to the well casing. A blower located at the WTTP provides the vacuum for extraction.

Prior to installation of this permanent system, a treatability study was conducted using the same well to evaluate the effectiveness of vacuum dewatering for source area mass removal. Vacuum dewatering is similar to DPE in that both water and soil vapor are extracted simultaneously. The difference between the two technologies is in the method of extraction.

Vacuum dewatering utilizes a vacuum tube, much like a “straw,” to extract groundwater and soil vapor simultaneously and in the same pipe using applied vacuum.

The results of the Vacuum Dewatering Treatability Study are documented in the Final *DP039 Phase Two Vacuum Dewatering Treatability Study Report* (CH2M HILL, 2002g). The study removed approximately 496 pounds of VOCs over a 6-month period. On the basis of these promising results, the permanent, dual-phase system was constructed to address the residual contamination at the site.

6.4.3.1 Cost Evaluation

O&M costs for the DP039 remedial actions are included in the costs presented for the CGWTP system (Section 5.1.4.2).

6.4.4 DP039 Passive Remediation Studies

Several passive remediation systems are currently in various stages of evaluation at Site DP039, including the following:

- Permeable Reactive Treatment Wall
- Phytoremediation Treatability Study
- MNA

Each of the three passive systems is described briefly in the following sections.

6.4.4.1 Permeable Reactive Treatment Wall

The construction and short-term (2 years) performance evaluation of a columnar-type jetted permeable reactive treatment wall near Building 755 at Site DP039 are documented in *Demonstration of a Columnar Wall Jet Grouting of a Permeable Reactive Treatment Wall,* (MACTEC, Inc., 2002).

The permeable reactive treatment wall at DP039 was designed to act as a permeable, reactive barrier to the migration of contaminated groundwater from the source area near the former sump. The wall is 91 feet long, 5 feet wide, and contains 161 tons of zero-valent iron (ZVI). The ZVI was placed in the wall so that approximately 5 feet of material are above the water table, and 35 feet below the water table. The water table is at approximately 20 feet bgs; therefore, the ZVI was placed from 15 to 50 feet deep.

Monitoring wells were installed immediately upgradient of the wall, within the wall, and immediately downgradient of the wall to evaluate performance. Monitoring was performed semiannually for 2 years.

Chemical data collected during this monitoring period from within the wall indicate the ZVI is reacting with the groundwater as predicted by laboratory tests. However, water quality data collected from upgradient and downgradient of the wall are similar; therefore, only a small fraction of the groundwater is likely passing through the wall. The data are inconclusive as to what fraction of the total groundwater flow may be bypassing the wall.

6.4.4.2 Phytoremediation Treatability Study

A phytoremediation study is in progress downgradient of the source area and the permeable reactive treatment wall. The Treatability Study Work Plan is documented in the *Technical Memorandum, Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Building 755* (Engineering Science, Inc., 2002).

The study at Travis AFB is part of a multi-site initiative being conducted by the Air Force Center for Environmental Excellence Technology Transfer Division to “develop a systematic process for scientifically investigating and documenting the potential for hydraulic control of groundwater contaminant plumes by the use of tree plantings” (Parsons Engineering Science, Inc., 2002). The initiative includes a number of other Air Force bases located throughout the United States.

In late 2002, Parsons Engineering Science, Inc., established a two-volume interim technical report that described the progress made and the data gaps that exist at all Air Force demonstration sites. For Travis AFB, initial findings were that the trees can survive in the climatic conditions found at the Base, and that the roots had reached the water table. However, the report concluded that there are insufficient data to support whether the trees are capable of controlling the solvent plume.

To answer this question, Parsons Engineering Science, Inc., initiated the first of several field efforts in December 2002, to improve the site characterization upgradient and downgradient from the trees, and to assess how the trees may be stabilizing the dissolved solvents. Data from this field effort are not yet available, and the study is ongoing.

6.4.4.3 Monitored Natural Attenuation

The downgradient portion of Site DP039 was designated for MNA in the *Groundwater IROD for the WABOU* (Travis AFB, 1999). As part of the preparation of a Natural attenuation assessment work plan for this site, several monitoring wells were installed to facilitate ongoing groundwater monitoring. This monitoring is part of the ongoing natural attenuation assessment during the interim period.

The main objective of MNA is Migration Control. The ongoing assessment is designed to measure the success of this objective and determine whether the downgradient portion of the plume at DP039 is continuing to migrate, or is stable. Monitoring is conducted as part of the GSAP, and a conclusion is drawn annually in the GSAP Annual Report. Currently, insufficient data are available to draw conclusions regarding MNA at DP039. When sufficient data are available, a Natural Attenuation Summary Report will be prepared that will recommend whether MNA should be selected as the final remedy at DP039 (CH2M HILL, 1998c).

6.4.5 Groundwater Monitoring

The following sections summarize the hydrogeology of Site DP039 and results of groundwater monitoring and modeling conducted in the area of the DP039 GET system and MNA. A comprehensive description of hydrologic and contaminant data collected at the site is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2003a). Groundwater modeling performed in support of the five-year review is described in detail in Appendix A.

6.4.5.1 Site Hydrogeology

Site DP039 is located on the eastern flank of an outcrop of the Tehama Formation (low hills) west of the WIOU. Ancient streams eroded the Neroly Sandstone underlying the WIOU to form a south-southeast trending valley in the bedrock surface (Figures 2-1 and 2-2). The area was subsequently overlain by alluvium as described in Section 2.1. Alluvium is 35 to 55 feet thick in the western portion of DP039 (based on drilling). The thickness of alluvium generally increases to the southeast. Alluvium is composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay. Sand and silty sand were derived from nearby Neroly Sandstone.

The West Branch of Union Creek runs north to south between the WABOU and WIOU (Figure A-3 in Appendix A).

6.4.5.2 Hydraulic Data and Modeling Results

The water table is approximately 10 to 17 feet bgs outside the area of groundwater extraction well EW563x39. In the vicinity of the extraction well, the water table is up to 28 feet bgs. Groundwater levels have declined in the area of DP039 since 1997 (prior to groundwater extraction at the site). Declining groundwater levels may be largely due to pumping in the WIOU. On a seasonal basis, the elevation of the water table varies 2 to 4 feet.

Figure 6.4-2 shows water table elevation contours at DP039 during the May 2002 GSAP monitoring event. This figure also shows the extent of hydraulic capture anticipated at DP039 as a result of groundwater extraction (based on modeling performed during the design of the extraction wellfield) and the estimated extent of hydraulic capture occurring in 2001 (based on modeling performed during the five-year review).

Table 6.4-2 presents conclusions concerning hydrologic conditions in the area of the DP039 GET system and MNA drawn from review of hydraulic data and the results of groundwater flow modeling.

TABLE 6.4-2
Conclusions Concerning Hydrologic Conditions in the Area of the DP039 GET System and MNA
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is approximately 10 to 17 feet bgs outside the area of extraction well EW563x39. In the vicinity of the groundwater extraction well, the water table is up to 28 feet bgs.
2.	Regional groundwater flow is southeasterly.
3.	Directions and rates of groundwater flow vary across DP039, largely due to pumping at EW563x39. Lateral hydraulic gradients vary from approximately 0.004 foot/foot outside the area of the extraction well to ≥ 0.01 foot/foot near the extraction well.
4.	Flow modeling indicates that the zone of hydraulic capture created by pumping at EW563x39 likely extends approximately 125 feet east, 100 feet south, 175 feet west, and upgradient to the north-northwest as shown on Figure 6.4-2.
5.	Based on the results of groundwater level monitoring and flow modeling, groundwater contamination in the source area at DP039 is being captured by EW563x39. However, VOC contamination ≥ 1,000 µg/L has been detected southeast of EW563x39 at the site. Additional pumping at EW564x39 (currently offline) is not likely to result in the capture of all groundwater contamination (≥ 1,000 µg/L).
6.	If contaminated groundwater at DP039 migrates southeast, it may be eventually captured by SD037, SS041, and SD043 extraction wells.
7.	EW564x39 (see Figure 6.4-1) is currently offline, and has no effect on groundwater conditions in this area.

6.4.5.3 Groundwater Quality Data

Figure 6.4-3 shows TCE concentrations detected in the May 2002 GSAP event. Figures 6.4-4 and 6.4-5 present time series plots of TCE and 1,1-DCE concentrations over time in selected DP039 extraction and monitoring wells.

The main objective of groundwater monitoring at GET sites at Travis AFB is to verify that the Source Control objective is being achieved. Ongoing groundwater monitoring at DP039 has been designed both to track the performance of the DPE system near the source area and assess MNA in the downgradient portions of the plume. Groundwater quality data collected from the monitoring network at DP039 as well as data collected as part of the *Permeable Reactive Treatment Wall Treatability Study* (MACTEC, Inc., 2002) support the conclusions summarized in Table 6.4-3. No groundwater quality data are currently available from the Phytoremediation Treatability Study.

TABLE 6.4-3
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	COC concentrations at EW563x39 and PZ01x39, located in the source area, are several orders of magnitude lower than the maximum historical concentrations detected at these locations (Figures 6.4-4 and 6.4-5).
2.	During the May 2002 GSAP event, 1,4-dioxane was detected at PZ01x39 at a concentration of 152 µg/L, significantly above the California Action Level. Although 1,4-dioxane from Site DP039 is probably diluted to concentrations below the action level at the CGWTP, the effluent of the plant should be analyzed for 1,4-dioxane to ensure that the chemical is not being released at concentrations exceeding the action level.
3.	The *Permeable Reactive Treatment Wall Treatability Study* was completed by the Air Force in June 2002. Data collected during the study indicate that concentrations of dissolved phase COCs within the reactive wall are significantly lower than upgradient concentrations (MACTEC, Inc., 2002). Groundwater elevation data and flow sensor data collected during the study suggested groundwater flows around the reactive wall.
4.	Well MW751x39, located approximately 80 feet downgradient of the permeable reactive wall, has exhibited trends of decreasing TCE and 1,1-DCE concentrations (Figures 6.4-4 and 6.4-5). These decreasing COC trends may be due to the reductive dehalogenation of COCs within the reactive wall.
5.	Although concentrations in the source area remain much lower than historical levels, contaminant concentrations in some plume monitoring wells downgradient of the source area (MW02x39, MW04x39, MW750x39, and MW759x39) have increased (Figures 6.4-4 and 6.4-5). This indicates that the plume is migrating in these areas.
6.	Concentrations of COCs downgradient of the phytoremediation area (especially in wells MW04x39 and MW759x39) are continuing to rise, indicating the plume is migrating in this area. However, concentrations at the downgradient edge of the plume remain below IRGs and are stable, indicating that migration is not occurring in this area. If the plume migrates farther to the southeast, the extraction wells at Sites SD037, SS041, and SD043 may be used to control the farther migration of contamination from DP039.

6.4.5.4 Time to Cleanup

Simulations of contaminant migration and estimates of the time to clean contaminated groundwater are approximate. They reflect available information describing the distribution of groundwater contaminants (and sources) and rates and directions of groundwater flow through the aquifer (present and future), in addition to the inherent limitations of technologies available to simulate contaminant transport in aquifers. In addition, the estimates are very conservative in that they do not take into account the effects that the reactive wall, phytoremediation, or natural attenuation may have on TCE concentrations.

Consequently, estimates of clean time are mainly of qualitative or comparative value and should not be taken as exact times to clean contaminated groundwater. Despite these limitations, cleanup times for TCE-contaminated groundwater in the area of DP039 have been estimated to facilitate the evaluation of the existing DP039 GET system.

The migration of TCE-contaminated groundwater originating in the area of DP039 has been approximated using a series of mixing cell calculations simulating the flushing of uncontaminated groundwater through contaminated portions of the aquifer and extraction of contaminated groundwater by DP039 extraction wells. Series of mixing cells were aligned with flowtubes based on the results of a steady simulation of groundwater flow performed using the updated Basewide Groundwater Flow Model (Appendix A). The initial (present-day) distribution of TCE at DP039 was estimated using groundwater quality data collected during the May 2002 GSAP monitoring event (Figure 6.4-3).

Simulations of TCE migration based on mixing cell (flushing) calculations are shown on Figure 6.4-6. The calculations suggest that TCE concentrations in the area of DP039 are likely to remain above 5 µg/L in excess of 100 years under current operating conditions. The figure also shows that TCE contamination migrating southward from DP039 will eventually be captured by the extraction system at SS041/SD043.

The results presented are based on the existing configuration of extraction wells at DP039. System optimization, including the installation of additional extraction wells in high-concentration areas, will reduce cleanup times. Ongoing monitoring, including monitoring the performance of the reactive wall and phytoremediation areas at DP039, will support and justify future optimization efforts.

The results presented represent best estimates of possible outcomes over long periods of time under current operating conditions, provided as a potential basis for identifying and prioritizing areas of future investigation. These results are based on recent refinements to the Basewide Groundwater Flow Model (Appendix A), subject to verification and evaluation using GSAP and other field data.

6.4.6 Opportunities for Optimization

Optimization of the remedial action at DP039 would be best evaluated when the Phytoremediation Treatability Study is eventually complete. However, several options could be considered for accelerated mass removal from this site, including but not limited to the following:

- Injection of an electron donor for enhanced bioremediation
- Injection of emulsified ZVI for abiotic and biotic degradation of any residual dense nonaqueous-phase liquid in the source area

The Reactive Wall Treatability Study is complete, and the results are inconclusive. Additional data are needed to evaluate the groundwater flow paths in the vicinity of the wall, and to assess whether TCE concentrations downgradient from the wall are declining because of the effect of the ZVI. Existing monitoring points that are up- and downgradient of the wall could be added to the GSAP to evaluate the permeability of the reactive wall. More monitoring wells might be needed in the future to draw firmer conclusions.

The installation of additional extraction wells in various portions of the solvent plume to optimize the existing extraction system should be considered after the Phytoremediation Treatability Study is complete. At least 2 more years are needed to complete this evaluation. At the present time, groundwater extraction in the vicinity of the phytoremediation area would have an adverse impact on the data collection efforts that are taking place in the study area.

Existing site data should be assessed to confirm that the vertical and horizontal extent of contamination is fully characterized. If data gaps are identified in the existing data, it may be necessary to collect additional data to optimize the remedial action.

The assessment of MNA is ongoing and will provide important information for making cleanup decisions in the downgradient portion of the solvent plume.

6.4.7 Technical Assessment

6.4.7.1 Is the Remedy Functioning as Intended by the IROD?

No. The DPE system in the DP039 source area has dramatically reduced contaminant concentrations in this area. Based on limited data, the reactive wall also appears to be having a positive impact on groundwater contamination, although more data are needed. The GSAP should focus on collecting groundwater elevation data to confirm flow paths and groundwater quality data to assess up- and downgradient changes in contaminant concentrations. The GSAP may also require the installation of additional monitoring wells, if needed, to obtain more detailed water elevation data.

The Phytoremediation Treatability Study is ongoing; therefore, it is too soon to draw conclusions regarding the effectiveness of this strategy in treating groundwater contamination. There is some indication that groundwater contamination might be migrating in the area downgradient from the phytoremediation area. However, guard wells along the down-gradient DP039 boundary all show low or no TCE concentrations. More time and data are needed to assess the various remedial strategies undergoing evaluation at DP039.

In summary, the Air Force will complete the following:

- Continue to evaluate the impact of the treatability studies on groundwater contamination at DP039
- Obtain more data through ongoing groundwater monitoring
- Install additional extraction or monitoring wells as appropriate

6.4.7.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are currently no exposure pathways to potential human or ecological receptors. The objectives of Source Control, Migration Control, and MNA are still valid.

6.4.7.3 Has Any Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. Travis AFB has delayed implementation of Phases 2 and 3 of the remedies specified in the WABOU IROD to complete three treatability studies at this site. Two of the studies are now complete and appear to have had a beneficial impact on the plume. For example, the Vacuum Dewatering Treatability Study resulted in TCE concentrations declining by two orders of magnitude in the source area. The Permeable Reactive Treatment Wall study appears to have resulted in a decline of nearly one order of magnitude in TCE concentrations in Well MW751x39, located downgradient from the wall.

The Phytoremediation Treatability Study is still underway, and more time is needed to assess its effect on the plume. Contamination appears to be migrating downgradient from the phytoremediation area, but so far concentrations are very low or nondetect in guard wells at the edge of DP039. Installation of additional extraction wells downgradient from the phytoremediation area may be possible, but Travis AFB must be careful not to impact the phytoremediation area by drawing down the water table or inducing oxygenated water to flow into the area. This work should only follow groundwater modeling and a careful assessment of possible impacts. The Air Force will assess additional actions needed to complete the interim remedy at DP039. Therefore, the remedy at Site DP039 should be considered protective on an interim basis.

6.4.7.4 Technical Assessment Summary

Full implementation of the IRAs specified in the *Groundwater IROD for the WABOU* has been deferred while data from two treatability studies and the MNA assessment are being collected at the DP039 site.

6.4.8 Statement of Protectiveness

The remedy at Site DP039 is expected to be protective of human health and the environment upon completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

6.4.9 References

CH2M HILL. 2003a. Final *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report.* Volumes 1 and 2. Installation Restoration Program. Travis AFB, California. 7 February.

CH2M HILL. 2001f. *DP039 Natural Attenuation Assessment Work Plan.* Travis AFB, California.

CH2M HILL. 2000e. Technical Memorandum: *DP039 Phase One Pilot Study Report, Travis AFB, California.* February.

CH2M HILL. 1999g. Final *Installation Restoration Program Groundwater Interim Record of Decision for the West/Annexes/Basewide Operable Unit*. Travis AFB, California. June.

CH2M HILL. 1998c. *Installation Restoration Program West/Annexes/Basewide Operable Unit Feasibility Study Final.* Travis AFB, California. April

MACTEC, Inc. 2002. Final *Demonstration of Columnar Wall Jet Grouting of a Permeable Reactive Treatment Wall*. June.

Parsons Engineering Science, Inc. 2002. Technical Memorandum: *Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Building 755.* 13 December.

Travis AFB. 1999. Final *Groundwater Interim Record of Decision for the West/Annexes/Basewide Operable Unit*. Installation Restoration Program. Travis AFB, California. 24 June.

Figure
6.4-1 DP039 Site Map
11 x 17 color

Figure 6.4-1 continued

Figure
6.4-2 Groundwater Elevations Measured at DP039 during May 2002
11x17 color

Figure 6.4-2 continued

Figure 6.4-3 TCE Distribution at DP039

11 x 17 color

Figure 6.4-3 continued

Figure
6.4-4 TCE Chemical Time Series Plots for DP039
8.5 x 11 b&W page 1 of 2

Figure 6.4-4 page 2 of 2

Figure
6.4-5 1,1-DCE Chemical Time Series Plots for DP039
8.5 x 11 b&w page 1 of 2

Figure 6.4-5 page 2 of 2

Figure
6.4-6 Time to Cleanup Simulation for TCE at DP039
11 x 17 color

Figure 6.4-6 continued

6.5 LF008 Groundwater Extraction and Treatment System

6.5.1 Site Description

LF008 consists of burial trenches formerly used for the disposal of pesticide containers. LF008 is located within the Weapons Storage Area (Bunker A) in the western portion of the WABOU. Figure 6.5-1 shows LF008 and the locations of the monitoring wells. Bunker A is a secured area and is surrounded by a fence with a locked access gate. The LF008 site comprises about 1 acre of land in the northern portion of Bunker A. The burial trenches are covered with fill soil, and the ground surface is covered with moderately dense grass. The site is bordered on the north and west by open grassy fields, and to the south and east by earth-covered bunkers used to store munitions. A paved access road that services the munitions bunkers traverses the southeast side of the site. No storm or sanitary sewer pipelines are located in the vicinity. An underground gas pipeline traverses the northeast portion of the site in a generally north to south direction (CH2M HILL, 2000f).

During the 1970s, approximately 30 cubic yards of materials were buried in trenches of varying dimensions. During the WABOU RI, geophysical surveys were used to identify the approximate locations of these historical trenches. Exploration trenching was conducted at nine locations, and two soil borings were drilled to groundwater. Six of the nine trenches encountered buried debris. The depth of the debris ranged from approximately 5 to 8 feet bgs. No lining was observed beneath the debris. Materials excavated included 1- and 5-gallon metal containers, plastic and paper bags, other paper and plastic debris, 1-gallon glass bottles, and two 55-gallon drums. Labels found on some of the containers indicated that the containers originally held pesticides and herbicides. No evidence indicated that other contaminants were disposed of in the trenches at Site LF008 (CH2M HILL, 2000f).

Table 6.5-1 lists the COCs at Site LF008.

TABLE 6.5-1
Chemicals of Concern at Site LF008
Groundwater Five-Year Review, Travis Air Force Base, California

Site	COCs
LF008	Aldrin, heptachlor, alpha-chlordane, heptachlor epoxide

Source: Travis AFB, 1999.

6.5.2 Site History and Status

Site LF008 was selected for GET in the *Groundwater IROD for the WABOU* (Travis AFB, 1999). The design of the extraction system is documented in the *LF008 Interim Groundwater Remedial Design Report* (CH2M HILL, 2000f). This report describes the objectives of this IRA as follows: (1) prevent the downgradient migration of groundwater contamination above IRGs using extraction wells near the leading edge of the plume, and (2) actively treat the more contaminated portion of the plume.

Conventional (i.e., vertical, no vacuum enhancement) groundwater extraction wells are being used to extract contaminated groundwater from the aquifer underlying LF008. Installation of extraction wells and monitoring wells was staged so that information collected during installation of the initial wells was used to select subsequent well locations. The system began normal operation on 25 May 2001.

Groundwater extracted at the site is conveyed to and treated at the CGWTP located at Site SS016 to the east. The CGWTP also treats contaminated groundwater from Sites SS016, SD033, SD034, SD036, SD037, DP039, SD041, and SD043.

6.5.3 Interim Remedial Action

6.5.3.1 Interim Remedial Action Objectives

Extraction/Treatment/Discharge is the selected alternative for Landfill 3 (LF008). This alternative uses standard pump-and-treat technology (Travis AFB, 1999).

6.5.3.2 Remedy Description

Three extraction wells were installed around the pesticide trenches to prevent contaminated groundwater from moving away from the site. These wells contribute a total of 1 to 3 gpm to the CGWTP flow via the WWTP (URS Group, 2002f). Extracted groundwater from the WWTP is transferred to the CGWTP for treatment and discharge.

6.5.3.3 Implementation

In June 2001, the three extraction wells from LF008 (EW719x08, EW720x08, and EW721x08) were brought online.

6.5.3.4 Operations

Operations issued for the CGWTP and WWTP are addressed in Table 5.1-2.

6.5.4 Groundwater Treatment

6.5.4.1 LF008 Groundwater Remediation System

The remedial action at LF008 currently consists of three extraction wells. Extracted groundwater from the wells is conveyed to the WTTP and then transferred to the CGWTP for treatment.

6.5.4.2 Cost Evaluation

O&M costs for the LF008 remedial actions are included in the costs presented for the CGWTP system (Section 5.1.4.2).

6.5.5 Groundwater Monitoring

The following sections summarize the hydrogeology of Site LF008 and results of groundwater monitoring and modeling conducted in the area of the LF008 GET system. A comprehensive description of hydrologic and contaminant data collected at the site is presented in the *GSAP 2001-2002 Annual Report* (CH2M HILL, 2002a). Groundwater modeling performed in support of the five-year review is described in detail in Appendix A.

6.5.5.1 Site Hydrogeology

Site LF008 is located on an outcrop of the Tehama Formation (low hills) west of DP039 (Figures 2-1 and 2-2). The surrounding area is overlain by approximately 65 feet of alluvium composed of discontinuous beds of sand and silty sand suspended in a matrix of fine-grained silt and clay (Section 2.1). Ground surface is 80 to 84 feet above mean sea level in the area of the LF008 burial trench and generally slopes toward the northwest and south.

6.5.5.2 Hydraulic Data and Modeling Results

The water table is 25 to 36 feet bgs at LF008. On a seasonal basis, the elevation of the water table varies approximately 2 feet. Groundwater levels had been declining at LF008 since January 1999. However, groundwater elevations have not fallen below historical levels and, over the last year, appear to be recovering.

Figure 6.5-2 shows water table elevation contours at LF008 during the May 2002 GSAP monitoring event. This figure also shows the estimated extent of hydraulic capture occurring in 2001 (based on modeling performed during the five-year review). Vertical hydraulic gradients have been evaluated at LF008 using groundwater level measurements in shallow and deep well pairs.

Table 6.5-2 presents conclusions concerning hydrologic conditions in the area of the LF008 GET system that were drawn from review of hydraulic data and the results of groundwater flow modeling.

TABLE 6.5-2
Conclusions Concerning Hydrologic Conditions in the Area of the LF008 GET System
Groundwater Five-Year Review, Travis Air Force Base, California

	Hydraulic Conclusions
1.	The water table is approximately 25 to 36 feet bgs.
2.	LF008 is located in an area of elevated bedrock (low hills) on a groundwater divide. Groundwater appears to flow northwest, southwest, and southeast from the area of the LF008 burial trench.
3.	Directions and rates of groundwater flow vary across LF008 due to its location on a groundwater divide, as well as pumping at LF008 groundwater extraction wells. Lateral hydraulic gradients vary from approximately ≤ 0.002 foot/foot outside the area of extraction wells to ≥ 0.02 foot/foot near extraction wells.
4.	Flow modeling indicates that the zone of hydraulic capture created by pumping at LF008 groundwater extraction wells likely extends less than 50 feet south of EW721x08 and approximately 125 feet, 225 feet, and 200 feet west, north, and east of EW719x08, respectively, as shown on Figure 6.5-2.
5.	Significant vertical hydraulic gradients (greater than ± 0.05 foot/foot) have been detected at LF008 in shallow/deep well pairs MW01x08/MW712x08 (downward) and MW115x08/MW311x08 (downward). Downward hydraulic gradients are consistent with LF008's location on a groundwater divide in an area of elevated bedrock.

6.5.5.3 Groundwater Quality Data

Figure 6.5-3 shows alpha-chlordane concentrations detected in the May 2002 GSAP event at Site LF008. Figure 6.5-4 presents time series plots of alpha-chlordane concentrations over time in selected LF008 monitoring and extraction wells.

The main objective of monitoring at Site LF008 is to evaluate the performance of the extraction system, including whether it is controlling plume migration and restoring groundwater quality. Groundwater quality data collected from the monitoring network at LF008 support the conclusions summarized in Table 6.5-3.

TABLE 6.5-3
Summary of Groundwater Quality Conclusions
Groundwater Five-Year Review, Travis Air Force Base, California

	Groundwater Quality Conclusions
1.	Concentrations of alpha-chlordane, the only site COC consistently detected in site extraction wells, has been declining at all three extraction wells (Figure 6.5-4). The most recent alpha-chlordane detections in extraction wells (December 2001) were just slightly above the IRG (0.1 µg/L). These declining concentrations and inconsistent detections of other site COCs indicate the extraction system is remediating the groundwater, at least in the immediate vicinity of the extraction wells.
2.	The highest pesticide concentrations detected during the 2001-2002 GSAP were in samples collected from well MW712x08. Pesticide concentrations in this well have been stable or decreasing, indicating that the plume is not continuing to migrate in this area (Figure 6.5-4).
3.	In the 2001-2002 GSAP, LF008 COCs were only detected in two monitoring wells other than MW712x08. These were MW715x08 and MW717x08. While COC concentrations exceeded IRGs in both of these wells, site COCs were only consistently detected at concentrations exceeding IRGs at well MW717x08. Well MW717x08 is upgradient of extraction well EW720x08, which should prevent the further migration of pesticides in the vicinity of MW717x08. However, well MW715x08 is the farthest downgradient well at the site, and located downgradient of the modeled extent of hydraulic capture. Heptachlor epoxide was detected at a concentration of 0.02 µg/L in this well (the IRG is 0.01 µg/L) during the September 2001 GSAP event. However, no Site COCs were detected above IRGs at well MW715x08 in the subsequent November 2001, February 2002, or May 2002 GSAP events, indicating the toe of the plume is stable and perhaps receding.
4.	Analysis for VOCs at the Site in 2001 and 2002 confirm that VOCs are not a concern at the site. Pesticides remain the only site COCs.

6.5.6 Opportunities for Optimization

Although contaminant concentrations have been steadily decreasing over time in the LF008 extraction and monitoring wells, concentrations remain above IRGs, and continued operation at current flow rates is appropriate. No additional wells are needed for increased mass removal since the concentrations are decreasing steadily with the existing system and may be below IRGs in the next several years.

Soil remedial action to remove the buried pesticide containers is scheduled for 2003. Removal of this continuing source of groundwater contamination will support the effectiveness of the groundwater interim remedy.

6.5.6.1 Is the Remedy Functioning as Intended by the IROD?

Yes. The IRA of Migration Control is being met by the GET system operating at the LF008 site. Concentrations of the only COC still being consistently detected at the site, alpha chlordane, have been declining at LF008. Performance standards are being met, and ongoing O&M activities should maintain the effectiveness of the remedy. The plume is fully delineated and completely captured.

6.5.6.2 Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

Yes. There are currently no exposure pathways to potential human or ecological receptors. The Migration Control objective remains valid because contaminant concentrations still exceed the Interim Cleanup Goals specified in the *Groundwater IROD for the WABOU*. Standards have not changed, nor has the anticipated land use at LF008. No new human or ecological receptors have been identified. No new contaminants have been identified.

6.5.6.3 Has Any Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No. Data from operation of the LF008 GET system indicate that the system is effective at meeting IRA objectives. Risks are being effectively managed, and the site source area is scheduled for cleanup. LF008 is not potentially subject to natural disasters.

6.5.6.4 Technical Assessment Summary

The organochlorine pesticide plume at LF008 is being effectively captured by the GET system. However, the presence of the buried pesticide containers in the overlying soil constitutes a continuing source of groundwater contamination.

6.5.7 Statement of Protectiveness

The GET remedy at Site LF008 is expected to be, or is protective of, human health and the environment, and in the interim, exposure pathways that could result in unacceptable risk are being controlled.

6.5.8 References

CH2M HILL. 2002a. *Groundwater Sampling and Analysis Program, 2001-2002 Annual Report.* Travis AFB, California. November.

CH2M HILL. 2000f. *LF008 Interim Groundwater Remedial Design Report*. Travis AFB, California. September.

Travis AFB. 1999. Final *Groundwater Interim Record of Decision for the West/Annexes/Basewide Operable Unit*. Installation Restoration Program. Travis AFB, California. 24 June.

URS Group. 2002f. *Central Groundwater Treatment Plant 2001 Annual Report*. January.

Figure
6.5-1 LF008 Site Map
8.5 x 11 color

Figure 6.5-1 back

Figure
6.5-2 Groundwater Elevations Measured at LF008 during May 2002
8.5 x 11 color

Figure 6.5-2 back

Figure
6.5-3 Alpha-Chlordane Distribution at LF008
8.5 x 11 color

Figure 6.5-3 back

Figure
6.5-4 Alpha-Chlordane Chemical Time Series Plots for LF008
8.5 x 11 b&w

SECTION 7.0

Summary

This section provides a summary of the first five-year review performance evaluation for each of the groundwater IRAs constructed or planned at Travis AFB.

7.1 Interim Remedial Action Performance Evaluation Summary

The primary purpose of the five-year review is to assess whether the interim groundwater remedies constructed at Travis AFB are protective of human health and the environment and are functioning as designed. Table 7.1-1 summarizes the following basic information:

- The IRA objective specified for each site in the applicable *Groundwater IROD for the NEWIOU* or *Groundwater IROD for the WABOU*
- A statement of whether the interim remedy is meeting the IRA objectives
- A statement of whether the interim remedy is, or is expected to be, protective (all sites are currently considered protective)
- Deficiencies identified during the review
- Specific actions needed to ensure that a remedy will be, or will continue to be, effective

A Five-Year Review Summary Form is provided at the end of this section.

7.2 Overall Statement of Protectiveness

The following three questions are incorporated into the technical review of remedy performance at each site:

1. Is the remedy functioning as intended by the IROD?
2. Are the exposure assumptions, toxicity, data, cleanup levels, and remedial action objectives still valid?
3. Has any other information come to light that could call into question the protectiveness of the remedy?

The answers to these questions are "Yes," "Yes," and "No," respectively, for all of the groundwater sites at Travis AFB.

7.2.1 Fully Implemented Interim Remedial Actions

Each of the fully constructed and operating groundwater IRAs at Travis AFB is meeting the objectives specified in the applicable *Groundwater IROD for the NEWIOU* or *Groundwater*

IROD for the WABOU. These IRAs are operating as intended and are deemed protective of human health and the environment. These IRAs and IRP sites include the following:

- **North IRA –** IRP Sites FT004, SD031, LF006, LF007B, and LF007D
- **South IRA –** IRP Sites FT005, SS030, SS029, ST032, southern portion of SS016, and FT005-offbase
- **Central IRA –** Northern portion of IRP Site SS016
- **West IRA –** IRP Sites SS014, SD033, SD034, SS035, SD036, SD037, SS041, SD043, and LF008

7.2.2 Pending Interim Remedial Actions

Through 2002, groundwater IRAs have not yet been fully implemented at several IRP sites identified in the applicable *Groundwater IROD for the NEWIOU* or *Groundwater IROD for the WABOU*. Therefore, these IRAs cannot be fully evaluated in this first five-year review. When these IRAs are fully constructed and operating normally, they are expected to meet IRA objectives and be protective of human health and the environment. Thus, pending IRAs include the following:

- **North IRA –** IRP Site LF007C (implementation planned for summer 2003)
- **South IRA –** IRP Site FT005-offbase (implementation planned for summer 2003)
- **Central IRA –** None
- **West IRA –** IRP Site SS015 and Site DP039

Additionally, three POCO sites are grouped into IRAs for future RBCAs in accordance with the *POCO Sites Work Plan*. No IRA has been implemented at these sites through 2002, and they are not evaluated in this first five-year review. These POCO IRAs include the following:

- ST018 RBCA
- ST027 RBCA
- ST028 RBCA

7.3 Next Five-Year Review

Remediation of contaminated groundwater sites at Travis AFB is being performed under IRODs, as opposed to final RODs. These interim actions were designed and constructed to accomplish the following objectives:

- Quickly begin remediation of groundwater contamination
- Gain control over sources of contamination
- Prevent further migration of plumes
- Clean up offbase contamination
- Reduce the levels of contamination and potential risk
- Collect data necessary to select final cleanup goals
- Collect data necessary to select technically and economically feasible long-term actions

TABLE 7.1-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	**Site**	**Source Control**	**Migration Control**	**Offbase Remediation**	**MNA[b]**	**MNA Assessment[c]**	**Are Interim Remedial Action Objectives Met?**	**Is Interim Remedy Protective?[d]**	**Deficiencies**	**Optimization Opportunities/Further Actions**	**Comments**
North IRA	FT004	Ö				Ö[e]	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass.	GET and MNA are considered successful at FT004 and SD031.
	SD031	Ö				Ö[e]	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Install additional monitoring wells southeast of EW567x31. Expand soil vapor treatment capacity.	
	LF006				Ö		Yes	Yes	None	Continue natural attenuation assessment monitoring.	MNA is successful at LF006.
	LF007B					Ö	Yes	Yes	None	Continue natural attenuation assessment monitoring.	MNA is successful at LF007B.
	LF007C		√	√		√[f]	**No**	**Yes**	**LF007C IRA construction not complete.** Onbase extraction wells and performance monitoring wells installed during fall/winter 2002, but system is not yet operational, and construction of offbase monitoring wells has not begun.	Construct remaining extraction system components and conveyance pipeline to the NGWTP in summer 2003. Conduct offbase plume delineation and performance monitoring well installations in summer 2003. Obtain easement onto the privately owned offbase property prior to beginning construction.	MNA has not been successful at LF007C; GET will replace MNA at this site.
	LF007D					Ö	Yes	Yes	None	Continue natural attenuation assessment monitoring.	MNA is successful at LF007D.
South IRA	SS030	Ö	Ö	Ö			Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Install additional monitoring wells to monitor performance of new extraction wells. Assess in situ technologies to reduce contaminant mass in source area.	Contaminant plume mostly underlies offbase private property. GET has protected drinking water supply in this area.

TABLE 7.1-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	**Site**	**Source Control**	**Migration Control**	**Offbase Remediation**	**MNA[b]**	**MNA Assessment[c]**	**Are Interim Remedial Action Objectives Met?**	**Is Interim Remedy Protective?[d]**	**Deficiencies**	**Optimization Opportunities/Further Actions**	**Comments**
	SS029		Ö				Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas or to prevent migration from SS016. Install additional monitoring wells to monitor performance of new extraction wells Assess in situ technologies to reduce contaminant mass in source area.	SS029 Migration Control GET system constructed to prevent movement of contamination to nearby offbase private property, and is successful.
	ST032	Ö	Ö[e]			--[g]	Yes	Yes	None	Continue LTO of SS029 GET system and SBBGWTP. Continue ongoing assessment of free product. Continue ongoing RPO.	ST032 Source Control IRA for removal of floating jet fuel in one site monitoring well. SS029 Migration Control GET IRA hydraulically captures dissolved portion of ST032 plume. ST032 Migration Control IRA not required because the commingled OSA/TARA/Southern SS016/ST032 plume is hydraulically captured by SS029 Migration Control GET IRA.
	Southern SS016		Ö			--[g]	Yes	Yes	None	Continue LTO of SS029 GET system and SBBGWTP. Install additional extractions wells to stop southerly migration.	Southern SS016 natural attenuation assessment not implemented and is no longer applicable because SS029 Migration Control GET IRA hydraulically captures the commingled Southern SS016/ST032 plume.
	FT005-onbase		Ö				Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells.	
	FT005-offbase			Ö			No	Yes	FT005-offbase IRA construction not complete. Onbase extraction wells and performance monitoring wells have been installed, but system is not yet fully operational, and construction of additional offbase wells is pending.	Construct remaining extraction system components and conveyance pipeline to the SBBGWTP in summer 2003. Conduct offbase plume delineation and performance monitoring well installations south of Creed Road.	Completion of FT005-offbase plume delineation and installation of extraction system and performance monitoring wells planned for summer 2003.
Central IRA	Northern SS016	Ö					Yes	Yes	None	Evaluate replacement of the ThOx system with VGAC. Evaluate replacement of UV/Ox and LGAC with air stripper. Consider in situ technologies in source areas to reduce mass.	OSA and TARA source area plumes[h] comprise the Central IRA. GET appears successful at achieving Source Control, although ongoing monitoring is needed.
West IRA	SS014[h]	Ö	Ö			Ö[e]	Yes	Yes	None	Continue LTO of free-product removal action.	POCO site. Source Control at Site 1 for removal of floating jet fuel.

TABLE 7.1-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	Site	Source Control	Migration Control	Offbase Remediation	MNA[b]	MNA Assessment[c]	Are Interim Remedial Action Objectives Met?	Is Interim Remedy Protective?[d]	Deficiencies	Optimization Opportunities/Further Actions	Comments
	SD033[i]		Ö			Ö	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass. Continue natural attenuation assessment monitoring.	SD033 plume is commingled with SD037 plume. GET and MNA appear successful at these sites, but ongoing monitoring is needed for confirmation.
	SD034[j]	Ö	Ö				Yes	Yes	None	Continue LTO of active skimmers.	Source Control for removal and hydraulic containment of Stoddard solvent. Floating product Migration Control for dissolved VOC plume.
	SS035[k]		Ö			--[g]	Yes	Yes	None	Continue LTO of GET system.	Natural attenuation assessment discontinued and no longer applicable because plume is hydraulically captured by SD037 Migration Control GET IRA.
	SD036[l]	Ö	Ö			--[g]	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass.	SD036 plume is commingled with SD037 plume.
	SD037[m]	Ö	Ö			Ö	Yes	Yes	None	Use groundwater modeling to adjust flow rates in existing extraction wells. Use groundwater modeling to identify locations for one or more new extraction wells closer to source areas. Consider in situ technologies to reduce source area contaminant mass. Continue natural attenuation assessment monitoring. Evaluate existing site data to confirm that extent of contamination is fully characterized.	SD037 plume is commingled with the SD033 and SD036 plumes.
	SS041[n]		Ö				Yes	Yes	None	Continue LTO of GET system.	
	SD043[o]		Ö				Yes	Yes	None	Continue LTO of GET system.	
	SS015					--	No	Yes		Investigate source, nature, and extent of contamination. Assess whether MNA is still a viable option for SS015.	Ongoing treatability study of enhanced biodegradation. New facility construction at site is planned for 2003.

TABLE 7.1-1
Summary of Five-Year Review Performance Evaluation
Groundwater Five-Year Review, Travis Air Force Base, California

		Interim Remedial Action Objective[a]					Five-Year Performance Review Criteria				
		GET System			Natural Attenuation						
IRA	Site	Source Control	Migration Control	Offbase Remediation	MNA[b]	MNA Assessment[c]	Are Interim Remedial Action Objectives Met?	Is Interim Remedy Protective?[d]	Deficiencies	Optimization Opportunities/Further Actions	Comments
	DP039	Ö	--[p]		Ö		No	Yes	None – downgradient extraction will capture any migrating contamination. The migration is currently confined to one portion of the site.	Complete phytoremediation treatability study. Assess in situ remediation in source area to reduce mass (electron donor and emulsified ZVI). Assess installation of additional extraction wells as appropriate. Evaluate existing site data to confirm that extent of contamination is fully characterized.	Ongoing phytoremediation treatability study and MNA assessment. More data needed. Completed treatability studies have included reactive wall and multi-phase extraction.
	LF008		Ö				Yes	Yes	None	Continue LTO of LF008 GET system	Noncontiguous, single-site plume.
ST018 RBCA	ST018						Not evaluated	Not evaluated	Not evaluated	Not evaluated	POCO site – not specified in IROD – pending RBCA.
ST027 RBCA	ST027						Not evaluated	Not evaluated	Not evaluated	Not evaluated	POCO site – not specified in IROD – pending RBCA.
ST028 RBCA	ST028						Not evaluated	Not evaluated	Not evaluated	Not evaluated	POCO site – not specified in IROD – pending RBCA.

[a]IRA objective specified in the Groundwater IRODs for the NEWIOU and WABOU.
[b]MNA was selected in the IROD.
[c]MNA is being assessed during the interim period.
[d]Detailed statements of protectiveness are provided in site-specific sections.
[e]IRA not specified in the *Groundwater IROD for the NEWIOU*, but implemented by the Air Force to address entirety of commingled plume.
[f]Assessment of MNA will continue in the interior portion of the plume.
[g]Assessment of MNA not implemented or has been discontinued because the site plume is hydraulically captured by an adjacent GET system.
[h]POCOS Site SS014 comprises five noncontiguous sites, including Sites 1, 2, 3, 4, and 5. Only Site 1 has a Source Control objective (floating jet fuel).
[i]IPR Site SD033 comprises five noncontiguous sites: Facility 810, Facility 1917, Storm Sewer System II, the South Gate area, and the West Branch of Union Creek.
[j]IRP Site SD034 is associated with Facility 811.
[k]IRP Site SS035 is associated with Facilities 818 and 819.
[l]IRP Site SD036 is associated with Facilities 872, 873, and 876.
[m]IRP Site SD037 is associated with the Sanitary Sewer System; Facilities 837, 838, 919, 977, 981; the Area G Ramp; and the Ragsdale/V Street area.
[n]IRP Site SS041 is associated with Facility 905.
[o]IRP Site SD043 is associated with Facility 916.
[p]Deferred – Migration Control not implemented pending evaluation of MNA and treatability studies.

Interim actions undertaken to date have successfully met these objectives. However, the interim actions should continue for another five years before considering a ROD, for the following reasons:

1. This review was triggered by the initiation of the first IRA following the signing of the *Groundwater IROD for the NEWIOU*. However, at most sites, groundwater actions have been underway for fewer than five years. At some sites (e.g., FT005-offbase and LF007C), IRAs have not yet been completely constructed. More time is needed to observe the impact of these actions on groundwater contamination at Travis AFB.
2. MNA has been selected as an interim remedy only at LF006. At other sites, MNA is being assessed during the interim period. The key question addressed in the assessment at these sites is whether the plumes are continuing to migrate, or are stable. The existing data are sufficient to state that MNA appears successful at stabilizing the plumes at LF006, FT004, SD031, LF007B, and LF007D. Conversely, additional analytical data are needed to confirm that the commingled SS014, SD033, and SD037 plumes; the SS015 plume, and the DP039 plume are stable and that MNA is halting plume migration at these sites. At LF007C, contamination has migrated offbase, and concentrations onbase have increased. However, GET is under construction in this area, which will address the problem. MNA has been formally selected in the NEWIOU Groundwater IROD as the interim remedy only at LF006 and DP039. For the other sites, a Natural Attenuation Summary Report will be prepared in the future that will make recommendations whether MNA should be selected as a final remedy. The Natural Attenuation Summary Reports will be prepared in accordance with the Natural Attenuation Assessment Plan.
3. The selection of final cleanup levels is a complex question that involves issues of risk and technical and economical feasibility. More data are needed to resolve these questions.
4. Groundwater remediation may be optimized at many sites, as noted in this document. The IRODs are flexible enough to permit this optimization, and optimization should be an ongoing process. Another 5 years will allow time to observe the effects of optimization.
5. Treatability studies are underway at several sites (e.g., SS015 and DP039). These studies need to be completed and evaluated before IRAs (or remedial actions) can be implemented.

The second five-year review of groundwater IRAs at Travis AFB is currently scheduled for 2008. It is anticipated that after the second five-year review there will be sufficient data to support the development of the Final Basewide Groundwater ROD. This ROD will be prepared by the Air Force in cooperation with U.S. EPA, San Francisco Bay RWQCB, and California Department of Toxic Substances Control, who will stipulate the final groundwater cleanup concentrations and remedial actions at Travis AFB.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name (*from WasteLAN*): Travis Air Force Base		
EPA ID (*from WasteLAN*): CA5570024575		
Region: 9	**State:** CA	**City/County:** Fairfield/Solano

SITE STATUS
NPL status: Final X Deleted Other (specify) ____________
Remediation status (choose all that apply): Under Construction __ Operating X Complete __
Multiple OUs?* YES X NO Construction completion date: 12 / 31 / 2003
Has site been put into reuse? YES NO X

REVIEW STATUS	
Lead agency: EPA State Tribe Other Federal Agency U.S. Air Force	
Author name: CH2M HILL	
Author title: N/A	**Author affiliation:** N/A
Review period:** 01 / 01 / 2003 to 07 / 15 / 2003	
Date(s) of site inspection: Site inspection ongoing	
Type of review: X Post-SARA Non-NPL Remedial Action Site Regional Discretion	Pre-SARA NPL-Removal only NPL State/Tribe-lead
Review number 1 (first) X 2 (second) __ 3 (third) __ Other (specify) ____________	
Triggering action:	
X Actual RA Onsite Construction at NEWIOU Construction Completion Other (specify)	Actual RA Start at OU# Previous Five-Year Review Report
Triggering action date (*from WasteLAN*): 07/1998	
Due date (*five years after triggering date*): 07/2003	

*["OU" refers to operable unit.]
**[Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

Five-Year Review Summary Form

Issues:

There are no issues related to protectiveness, only recommendations for optimization (see Table ES-1 and site-specific sections).

Recommendations and Follow-up Actions:

(See Table ES-1 and site-specific sections.)

Protectiveness Statement(s):

All site are considered protective (see Table ES-1 and site-specific sections).

Other Comments:

(None.)